ILLUMINATION TERMS

GENERAL · SALES · OFFICE · HARRISON · N · J ·

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY.

Illumination Terms

Information Compiled by
Engineering Department

Preface

Each of the arts and sciences has a vocabulary of terms peculiar to itself. These terms are, of course, defined in dictionaries and other books of reference. In addition, in any specialized field words and expressions in common use take on new shades of meaning through custom or mutual understanding within the profession.

Such a condition naturally exists in the lighting art, and in this pamphlet we have endeavored to present a glossary of illumination terms. Our first attempt along this line was in connection with a small Handbook on Incandescent Lamp Illumination issued in 1916. There, of course, due to space limitation, the treatment was by no means complete.

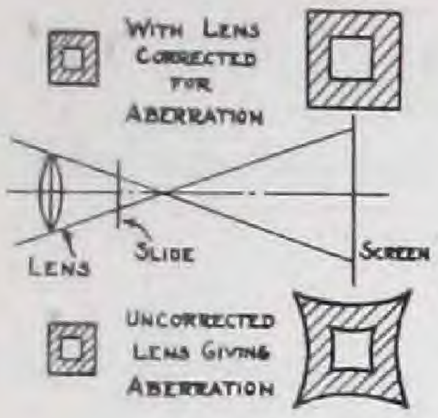
It is hoped that these definitions are expressed in a manner that is simple and easily understood, and it is believed that they are technically correct. For brevity, many terms that are used in the ordinary sense or whose meanings appear obvious, have been omitted.

The definitions presented in the American Engineering Standards Committee Report on "Illuminating Engineering Nomenclature and Photometric Standards" have been followed in all cases in which they apply and, as a rule, additional explanatory or illustrative material has been included.

The compilers recognize that concepts of individual experts vary somewhat and that, as a consequence, another group attempting the same task would, in numerous instances, have expressed themselves in slightly different fashion.

Stilted, pedantic definition has been avoided as far as possible in the endeavor to make the booklet of service to the practical non-technical man, as well as to the student.

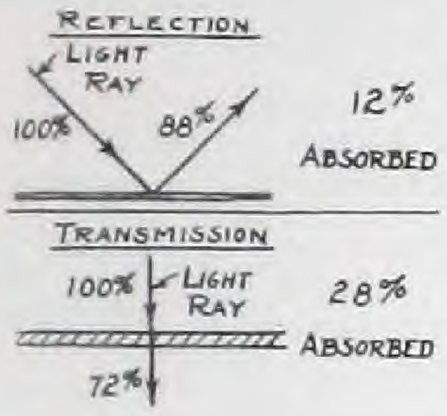
In this first edition it is possible that small errors of fact may have crept in, and, where such are noted, we should be glad to have our attention called to them.



Aberration

An effect, brought about by inaccuracies in the design of an optical system, in which the image produced by that system, instead of being sharply defined, has fringed or colored edges.

Aberration exists in two forms, one called *spherical*, where the overlapping edges exist, and the other known as *chromatic*, where the image is bordered by colored light.

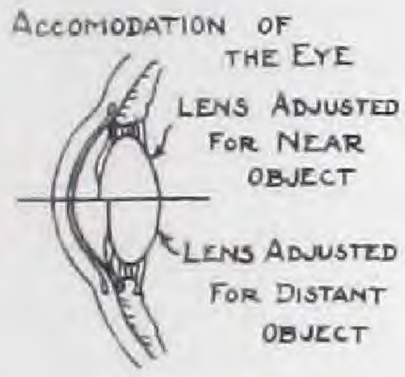


Absorption

The loss which results when light strikes any object or traverses any medium.

The lost, or *absorbed*, light is converted to heat, raising the temperature of the interfering body or medium. The percentage of incident radiation absorbed depends upon the wavelength of the radiation and the nature of the interfering object; density, opacity, physical structure, and surface smoothness being controlling factors.

The amount of light absorbed, expressed as a percentage of the total amount striking the object or medium, is known as the *absorption factor*.



Accommodation

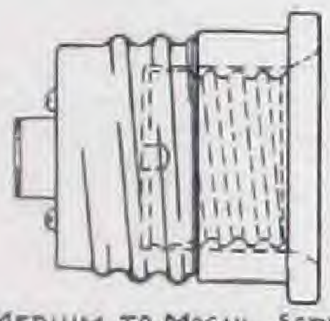
The adjustment of the eye for seeing at different distances. This is accomplished by means of a change in the shape of its lens, which, through muscular control, is flattened or bulged, as desired.

Actinic

The quality of light which enables it to affect chemical materials, as, for example, a photographic plate.

Adaptation

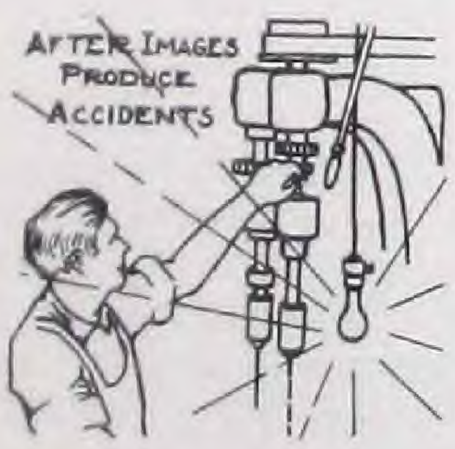
The adjustment of the eye according to the brightness of the field of view. This *adaptation* is accomplished by the opening or closing of the iris.



Adapter

A device for the fitting of an incandescent lamp with a certain size of base to a socket either smaller or larger than the base of the lamp. The *adapter* usually consists of a socket and plug base in combination, the socket being of the correct size to fit the lamp base, and the plug base being of the correct size to fit the lamp-holding device already installed.

For permanent service, it is usually preferable to replace any special socket by one designed to accommodate a standard lamp base. (*See also Socket Extension.*)



After Image

An image impressed upon the retina of the eye after a very bright object or brilliant light source has been looked at for a while: the color of this image is complementary to that of the object or source that has been viewed. This *after image* persists for some time, preventing clear perception of detail, and, if severe, obscures everything else.

High wattage bare lamps in the field of view, in the machine shop, for example, produce after images which are often the cause of serious accident through the consequent inability of the workmen to see dangerous moving parts.

Ageing

The process of seasoning new lamps before submitting them to photometric or other tests. The lamps are burned at or above normal voltage until their wattage and candlepower have reached stable values.

Alignment

In optics, the exact centering of all the elements (as, for example, a train of lenses) with respect to the optic axis.

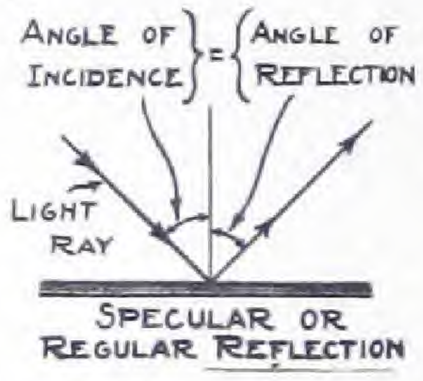
This centering, or *alignment*, of the elements is of the utmost importance in order that unnecessary loss of light may be avoided. (*For illustration see Objective Lens.*)

Aluminum Finish

The painting, or spraying, of the inside surface of a shade or reflector with aluminum.

Polished aluminum has a reflection factor of about 65 per cent, and aluminum paint, about 50 per cent. Polished aluminum acts by regular reflection, while the pebbly surface of aluminum paint gives spread reflection.

Angle of Incidence



The angle made by any beam of light falling upon a surface with a line perpendicular to the surface at the point where the beam strikes; used to designate the direction of a beam of light.

Angle of Reflection

The angle made by any beam of light reflected by a polished surface, such as a mirror, with a line perpendicular to the surface at the *point of reflection* (which is also the *point of incidence*).

Angle Reflector

ANGLE TYPE REFLECTOR

A form of reflector, usually of the deep bowl type, which is tilted with respect to the lamp and support so as to give a lateral distribution of light in one general direction; in other words, produce an asymmetric distribution.

Angle reflectors are commonly used where a wide area must be illuminated from the sides, or where it is desired to illuminate vertical surfaces—bulletins or poster panels, for example. For general purposes, *angle reflectors* are usually less efficient and more liable to produce glare than those having symmetrical distributions.

Angström Unit

A unit of length (one ten millionth of a millimeter) used to express the wavelength of light.

Thus, a certain part of the green in the spectrum has a wavelength of 5500 *Angström units.*

1000 Angström Units (A) = 100 millimicrons ($m\mu$) = 0.1 micron (μ)

Apparent Candlepower

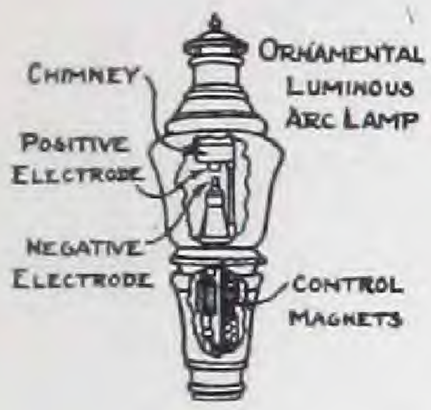
It is customary to designate the light intensity of an illuminant in *apparent candlepower* measured at some designated distance in cases where, because of the relatively large area of the light source, or the use of certain lenses or reflectors, the Law of Inverse Squares does not apply, and where, as a consequence, the intensity of light cannot be accurately stated in candlepower.

Apparent Foot-candles

A measure of the brightness of an object as the product of the incident intensity measured in foot-candles and the reflection factor of the object. In brightness measurements, which should be approached with caution, it is assumed always that the object under consideration either emits or reflects the light in a diffuse manner according to Lambert's Law (see *Brightness*).

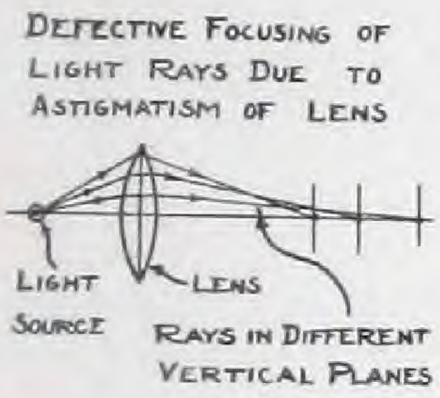
Approach Lighting

A system of railroad signal lighting employing a lamp which is lighted automatically on the approach of a train.



Arc Lamp

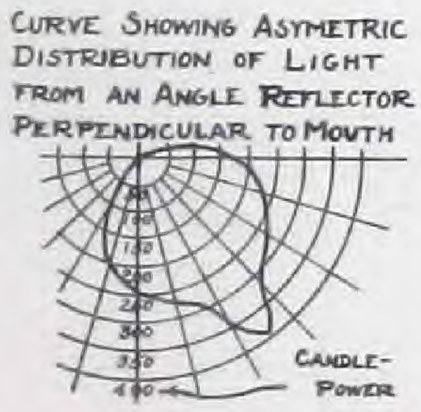
An illuminant in which light is produced by the flow of electricity across a gap between two electrodes, some of the electrode material being gradually vaporized to form the arc stream. The common forms are the: *Open Carbon, Enclosed Carbon, Flaming Carbon, Mercury Vapor, and Magnetite, or Luminous.*



Astigmatism

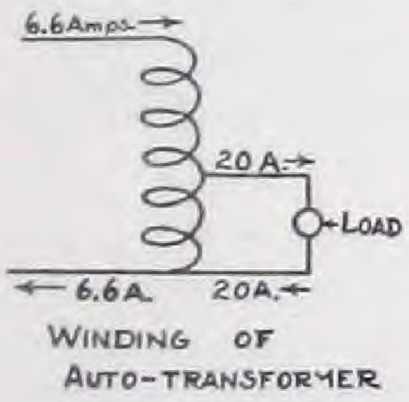
A cylindrical variation from the normal curvature of the eye or a lens which causes rays of light from one point to be brought to a focus at different points, often causing indistinctness of vision and imperfect images.

Astigmatism of the eye is identified by the fact that straight lines look more distinct and black when extending at certain angles than at others, the most indistinct line being at right angles to the most distinct line. *Astigmatism* is often measured by the curvature and direction of a cylindrical prism which corrects the condition.



Asymmetric Distribution

A distribution of light from a lamp or lighting unit in which the light in one or two compass directions is emphasized at the expense of the other directions. Examples of lighting equipment giving asymmetrical distribution are: angle reflectors used to emphasize the light on one side of the unit, highway units, and certain refractor units designed to emphasize the light up and down on highway or street and avoid wasting light on the adjacent areas, etc.



Auto-transformer

A transformer in which part of the winding serves as both primary and secondary. Such a device, used in connection with street lighting circuits, permits the use of a high current lamp on a lower current circuit, as for example, a 20 ampere lamp on a 6.6 ampere circuit. (*See Compensator.*)

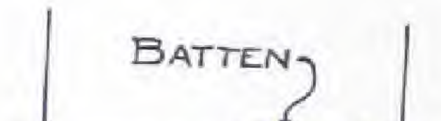
Axis

An imaginary straight line conceived of as a center of symmetry or rotation. For example, the *Axis* of a lamp or reflector is conceived to extend longitudinally through the mechanical center in such a way that the mechanical outline and the distribution of light generally are symmetrical with respect to the axis. The axis of an *Optical System* or Projector is a straight line passing through the center of the light source (and hence through the focal points, lenses, and reflectors composing the system). (*For illustration see Objective Lens and Parabolic Reflector.*)

Back-up Lamp

A small headlight installed on the rear of the tender of a locomotive. Its usual form is a lantern with a corrugated lens.

BANK OF FLOODLIGHTS



Bank

A group of floodlighting projectors at one location to permit the building up of intensity over a local area, or to reduce the wiring and maintenance expense incident to a system employing isolated units.

Bare Lamp

A lamp used without shade, reflector or globe.

BASES

Base

The metallic shell assembly by which a lamp is attached to the supporting socket and connected to the electric circuits. Bases are classified by size as follows: *Miniature*, *Candelabra*, *Medium*, and *Mogul*. The standard bases in the United States are of screw type, previously known as the Edison base. In automobile service, the bayonet candelabra base is standard.

The operating position of a lamp is often designated as *Base Down* or *Base Up*, according to the position of the base with respect to the body of the lamp. *Base Down* and *Base Up* correspond, respectively, to the former designations *Tip Up* and *Tip Down*.

Batten

A length of pipe hanging parallel to the floor of the theater stage which can be raised or lowered at will. To this is attached lighting equipment, scenery, etc.

Beam

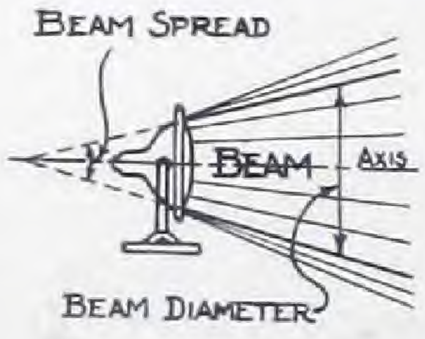
A cone of light—more or less approaching a cylindrical shape—as emitted from a lens, parabolic reflector, or other form of projection equipment. Such a beam is often rendered visible by dust, smoke, or moisture in the atmosphere. (*See Beam Diameter.*)

Beam Candlepower

The luminous intensity, as measured in candlepower, of a beam in any given direction within the beam limits.

When no particular direction is specified, the axis of the beam (or projector) is meant.

Beam Diameter



Unless a very small light source and a very precise lens, or mirror, is used to form a projection device, the resultant beam will not have its edges clearly defined. Such is usually the case when incandescent lamps are used. In order to specify the limits of the beam, it is now common practice to mark the edge of the beam as lying at that point where the candlepower falls to one-tenth of the maximum. (See *Beam Spread.*) The maximum candlepower is ordinarily found on the axis.

Beam Lumens

The total flux of light (see *Lumen*) contained in any beam. When compared with the total output of light from the lamp, it gives an idea of the efficiency of the projector and also facilitates illumination calculations.

Beam Spread

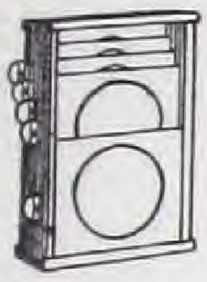
The angular divergence of a beam, measured in degrees.

Berth Light

A small lamp installed in recessed fixture in the side of a sleeping car to furnish light after the berths are made up.

Black Body

A theoretical object which is assumed to absorb completely all radiations falling on it, and, when raised in temperature, to radiate more energy throughout the entire spectrum than any other incandescent solid. Color of light is sometimes expressed in terms of degrees of absolute temperature to which a black body must be raised to emit light of the given color. This is termed *Color Temperature.*



BOOMERANG

Boomerang

In theatrical lighting, a small box attached to the front of a spot lamp to hold color media, arranged so as to make a change of color convenient.

Border Light

A row of lamps, generally clear and colored (or equipped with color media), on several circuits, with suitable reflectors, hanging above the stage. The border light directs general illumination downward and slightly toward the rear. If such a border light hangs in front of the curtain, it is known as a *valance border.* The first border directly behind the curtain is known as the *concert border;* the others are known as first, second, and third borders, as backstage is approached. (*For illustration see Batten.*)

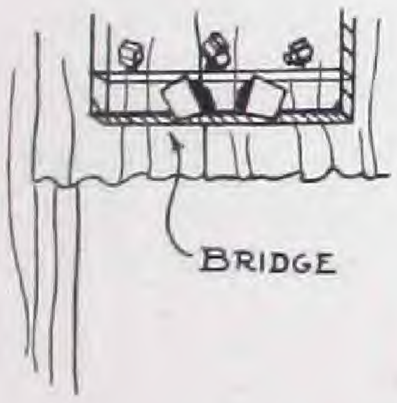
DEEP BOWL REFLECTOR

Boundary Lights

Clear or opalescent fixed lights of low candlepower spaced at regular intervals around the border of aviation fields to outline the contour of the field.

Bowl Reflector

A reflector having the general contour of a fairly deep bowl. Normally reflectors of this type are characterized by a lower cut-off than that of other forms.



Bridge

In the theater, a suspended or fixed platform above the stage from which lighting apparatus is manipulated.

Brightness

Any object emitting or reflecting light is said to be bright, and, through the fact of its brightness, is visible. Used in this sense, the term "bright" is purely qualitative, and, in order to fix the brightness of objects for comparison purposes, a quantitative scale is necessary.

To supply such a quantitative scale, the *brightness* of a surface when viewed in any direction is considered to be the ratio of the luminous intensity or flux—either emitted or reflected—expressed in candlepower or lumens measured in that direction, to the area of this surface projected on a plane perpendicular to the direction considered.

The brightness of a surface is always expressed in terms of luminous intensity per unit of projected area. The units used

to define it are the *lambert, millilambert, foot-lambert, candlepower per square inch, candlepower per square centimeter, apparent foot-candle*, and the *lux*. (See definitions of these terms.)

CONVERSION FACTORS FOR VARIOUS BRIGHTNESS VALUES

A	Candles per sq. cm.	Candles per sq. in.	Lamberts	Millilamberts	Foot-candles	Lux
Candles per sq. cm.	1	6.452	3.14	3141.6	2918	31416
Candles per sq. in.	.155	1	.4867	486.7	452	4867
Lamberts	.318	2.054	1	1000	929.03	10000
Millilamberts	.000318	.002054	.001	1	.929	10
Foot-candles	.000343	.00221	.00108	1.076	1	10.76
Lux	.0000318	.0002054	.0001	.1	.0929	1

Values in units in Column A times conversion factor equal values in units at top of other columns.

Brightness is independent of distance—which means that no matter at what distance from a light source, or other bright object, an observer places himself, it will appear always of the same brightness. The explanation for this lies in the fact that while the total quantity of light entering the eye varies inversely as the square of the distance between the observer and the object, the area of the image formed by the object on the retina of the eye varies in like proportion, so the intensity of this image remains constant. In other words, the brightness of the retinal image is always the same.

In the case of any object which emits or reflects light diffusely in accordance with *Lambert's Cosine Law of Emission* (see definition) the object will appear always of the same brightness, no matter at what angle it is viewed. Roughly, for the sake of simplicity, it is common to assume that Lambert's Law applies to ordinary objects (not polished) and to make a single determination of brightness from a mean direction, and assume this as the brightness of the object.

The entire subject of brightness is extremely complicated to persons not conversant with illumination practice, and, for this reason, it should be approached with caution so as to avoid misleading conclusions.

Brightness Contrast

In general, vision depends upon two things: a difference in the brightness of objects, and a difference in the color of objects. Two adjacent surfaces of the same color having a difference in brightness of less than one per cent will be seen as one surface.

At very low intensities (low brightness), the color of objects appears to undergo marked changes (see *Purkinje effect*).

Either *extreme brightness contrast* (difference in brightness), or *insufficient brightness contrast*, is inimical to continued comfortable vision, as, in the first case, it is impossible for the eye to adjust itself to the two extremes, and, in the second case, it is impossible for the eye to focus itself, and fatigue eventually results.

Brightness Ratio

The ratio of one bright surface to another. When both lie within the same field this ratio assumes importance, since it can be used as an indication of whether or not the visual conditions within that field are safe.

In general, it can be said that the brightness ratio of any two surfaces within the same field should not exceed 100 to 1 for comfortable vision.

Brilliancy

(*See Brightness.*)

Bulb

BULB

A glass container of special shape and size in which the filament of an incandescent lamp is placed.

Bulbs may be of colorless clear glass (referred to as *Clear Bulbs*), *Inside Frosted*, *Clear Colored* (e.g., blue), *Diffuse Colored* (red, flame tint, etc.). *Inside Frosted* finish is used in the range from 15 to 100 watts, superseding the clear, opal, and outside frosted bulbs, combining the advantages of diffusion with minimum absorption of light. The shapes of bulbs are designated by letters as follows:

A—The new pear shape
PS—Pear shape
G—Spherical
T—Tubular
S—Straight side.

The maximum diameter is designated by a figure indicating the number of eighths of an inch. Thus, A-19 designates the type of bulb used in the new Standard Line of Incandescent Lamps, having a diameter of nineteen 8ths of an inch, or $2\frac{3}{8}$ inches.

BUNCH LIGHT

Bunch Light

On the stage, a cluster of relatively small lamps mounted in a single reflector on a movable stand to direct a flood of light where needed. Now generally replaced by a single large lamp floodlight. *Cargo* lights on shipboard are of this general nature also.

Burn-out Curve

A graphic representation of the lives of a group of lamps, with hours as one co-ordinate and number of lamps still in service as the other. (*For illustration see Life.*)

Calcium Light

An apparatus (much used in stage lighting before the development of electric light) consisting of a piece of unslaked lime made intensely luminous by a very hot flame (oxy-hydrogen) and placed at the focus of a condenser lens. The beam which is thrown is powerful and uniform.

Candle

In illumination practice the word *Candle* refers to the *International Candle*, which is the unit of luminous intensity, and which resulted in the year 1909 from agreements effected between the three National Standardizing Laboratories of France, Great Britain, and the United States.

Since that time this unit has been maintained by means of standard incandescent lamps in these laboratories.

The *International Candle* is the same as the Pentane Candle, Bougie Candle, and American Candle.

1 International Candle = 1.11 Hefner Candles = 0.104 Carcel Units.

Candlepower is luminous intensity expressed in candles.

Candlepower Distribution Curve

The intensity of luminous radiation expressed in candlepower measured at various angles about a light source and graphically represented. (*For illustration see Distribution*).

Candlepower Maintenance

The extent to which a light source keeps up its initial intensity of luminous radiation throughout life. It is ordinarily taken as one criterion of the quality of a lamp.

Canopy

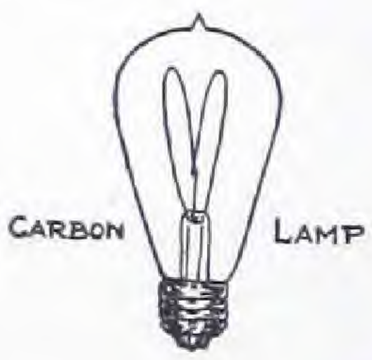
A covering, usually of cone-shaped metal, concealing wiring connections where the fixture joins the ceiling or wall. On a street lighting unit, a covering over the top opening of the enclosing globe.

Caps (Color)

A small colored glass bowl held by springs on the rounded end of a lamp in order that a certain color may be obtained in a sign, show window, on a theater stage, etc.

Carbon Lamp

An incandescent lamp the filament of which is homogeneous carbon in the form of fine thread.



Casing

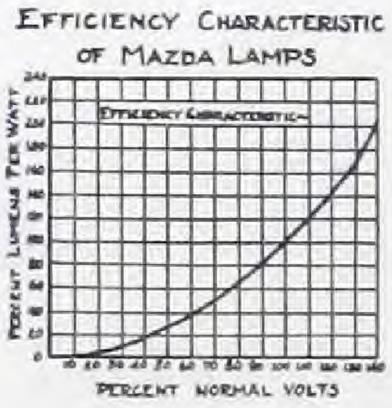
In street lighting, the metal form which is fastened to the top of an ornamental pole, and which holds in place a diffusing globe surrounding the lamp. (*For illustration see White Way lighting.*)

Ceiling Light

In aviation lighting a searchlight elevated to 45 degrees mounted on top of hangar or observation tower to indicate amount of ceiling, which in aviation nomenclature is the distance from the ground to clouds, haze, or fog.

Center Deck Lighting

A system of railroad car lighting in which the fixtures are placed in a single row down the center of the car.



Characteristic Curve

A curve expressing a relation between two variable properties of a light source, as, for example, candlepower and volts; amperes and volts, etc.

Classification Lamp

In railway practice, a signal lantern carried on the front or side of the smoke box of a locomotive, to indicate the class of train, such as regular, special, first or second section, etc.

Clear Lamp

An incandescent lamp having a clear, colorless glass bulb devoid of any diffusing finish.

Coated Colored Lamp

A lamp the emitted light of which is tinted as a result of passing through a thin layer of fine colored particles in a suitable suspension medium sprayed on the bulb. Such coating is diffusing, and conceals the filament more completely than the ordinary color dips.

Code of Lighting

A code of rules to be followed in obtaining proper artificial illumination, with special regard to safety. The Illuminating Engineering Society's *Code of Lighting for Factories, Mills and Other Workplaces* has come to be recognized as the American Engineering Standard and has been used as the basis of the codes drafted by the various states.

A *School Lighting Code* has also been prepared by the Illuminating Engineering Society and accepted as an American engineering standard. Such codes prescribe only the minimum requirements of safety and eye conservation. The levels prescribed are much lower than those recommended on the basis of efficient operation.

Coefficient of Reflection

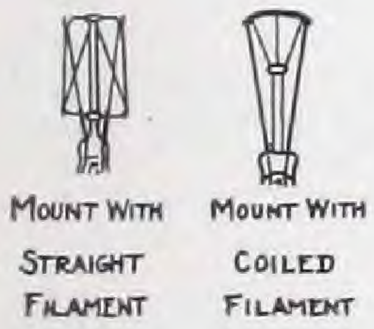
The ratio of the total light reflected by a surface to the total light falling upon it, expressed as a percentage. (*See Absorption.*)

Coefficient of Transmission

The ratio of the light transmitted by translucent and transparent objects to the total light falling upon them, expressed as a percentage.

Coefficient of Utilization

The ratio of the useful light (upon the working plane) in a room to the total light emitted by the lamps in that room, expressed as a percentage.



Coiled Filament

A lamp filament closely wound into the form of a helix before mounting in the lamp, as distinguished from one in which the wire is mounted uncoiled. *Coiled filaments* are commonly used in MAZDA C lamps, the new Standard Line, and in Concentrated Filament Lamps.

Color Filter

A screen of gelatine, glass, paper, fabric or other material through which light from a source passes. Through selective absorption the filter eliminates those rays or colors not desired, transmitting the resultant light of the color required. Thus a red filter absorbs violet, blue, green, yellow and orange rays, passing only the red rays.

Color Lighting

The use of different colors of light (usually red, green, blue, and yellow) to obtain spectacular illumination effects.

Color of Light

The subjective analysis or evaluation by the eye as to the particular part of the spectrum in which certain light or luminous flux belongs. Color can be expressed in terms of its *hue* and *saturation*, q. v. (*See also Black Body.*)

Color of Objects

The color of an object is the result of its capacity for reflecting light from certain parts of the spectrum in varying amount. A white object reflects all colors equally well. A black object tends to absorb all colors. A pure red object reflects the red portion of the spectrum, absorbing other colors, and so on. Thus, the appearance of color of an object will vary with the quality of the incident light and will depend on how much of each particular color is present in the spectrum of the light. The ordinary color designation of an object assumes daylight or white light.

Color-matching Units

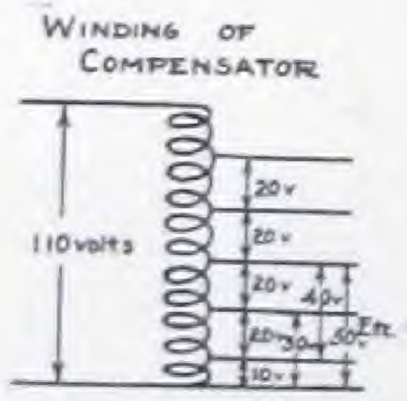
A piece of lighting apparatus designed to supply light of suitable quality to permit the matching or identification of colors, as in dyeing, dress making, etc. Ordinary daylight is subject to considerable color variation, so daylight from the north sky has generally been used by color specialists of the textile and other industries. *North sky light* has been generally preferred as a standard in the manufacturing industries because of its greater uniformity, although it is bluish as compared to average daylight. With the growing use of accurately reproducible color matching units, there is a growing tendency to use as standard a light in color which more nearly approximates that of average daylight. This has the further advantage that it is more easily and more efficiently produced from artificial light sources, such as the MAZDA C Lamp.

Color Temperature

A light source is said to have a certain *color temperature* when it emits radiation having the identical spectral characteristics of the theoretical black body at this given temperature.

Comparison Lamp

A lamp of constant, but not necessarily known, candlepower against which a working standard and test lamps are successively compared in a photometer.



Compensator

A single-coil transformer with a series of taps for operating lamps of a voltage lower than the circuit voltage in a multiple system, or of a current higher than the circuit current in a series system. Also, balancer coils for maintaining a voltage balance on a 3-wire circuit, as when 110-volt lamps are fed from a 220-volt circuit. The term is synonomous with *Autotransformer*.

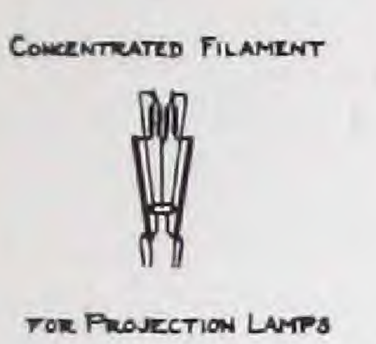
Complementary Color

Two colors are complementary if they may be mixed to produce white. White may be considered as a color having no hue. By the mixture of luminous fluxes of two or more hues properly chosen as to hue and intensity, a resultant luminous flux may be obtained which has the color white. Whenever luminous fluxes of two or more hues are mixed, the resultant luminous flux, though it may have some dominant hue, will ordinarily be evaluated subjectively as having an admixture of white.

Concentrated Distribution

This term is applied to the characteristic distribution of lighting units which emit the major part of their flux over a very narrow angle (about 10 degrees each side of the nadir).

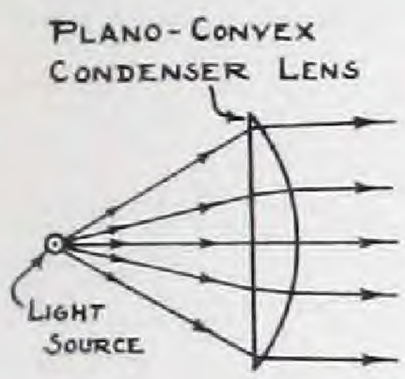
Concentrated Filament



A filament which is mounted in such a manner that the sections are as closely spaced as possible, without, however, incurring the danger of filament failure from arcing or short circuiting between sections. The shape of such filaments is governed by the service for which they are intended.

They are used principally for the projection in the form of concentrated beams of light for which purpose it is desirable that the light emanate from an approximation of the hypothetical "point source."

Condenser



A lens or combination of lenses used with a stereopticon or motion picture projector to collect light radiating from the source and bend it toward a central axis for projection through a slide into an objective lens. For effectiveness, the light source should be of small dimension.

Conical Distribution

The distribution of luminous flux over a solid angle having the shape of an annular cone—that is, a solid cone from which a central solid cone has been removed.

Constant Current Transformer

A transformer whose primary coil is connected to a constant voltage circuit and whose secondary coil, often movable, supplies a constant current (within the limits of its capacity) regardless of the number of lamps burning on a series circuit—employed principally in street lighting.

Contrast

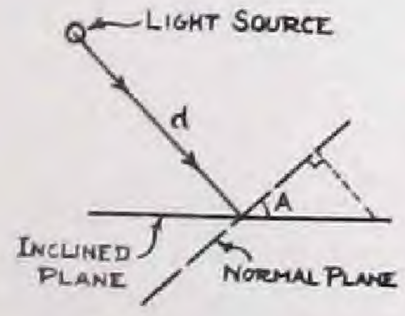
(See *Brightness Contrast.*)

Cosine Law of Emission

This refers to the distribution of luminous flux by light sources, and, in general, it may be said that all sources approximately obey this law. Its application rests upon the assumption that the light is emitted in a perfectly diffuse manner. If this assumption is made, then in the case of a flat surface emitting or reflecting light, the luminous intensity in any direction will be the brightness of the surface times the area of the surface times the cosine of the angle which that particular direction makes with the normal to the surface.

In reality, no surface is a perfect diffuser, so this law never strictly applies. (*For illustration see Diffuse Reflection.*)

Cosine Law of Illumination



When a shaft, or beam of light, falls upon a surface placed normal to the path of the beam, the illumination upon this surface will be the ratio of the luminous intensity, measured in candlepower, to the square of the distance between the light source and the surface.

This can be expressed in the form of an equation as follows:

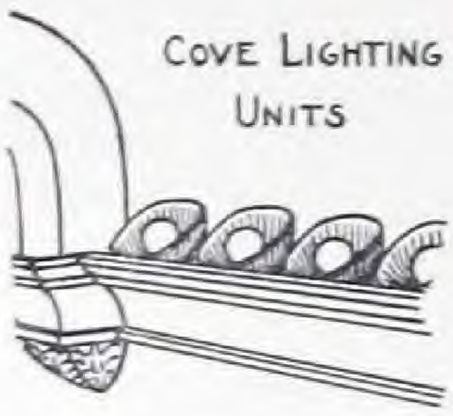
$$E = \frac{c.p.}{d^2}$$

If the surface is inclined at an angle to the beam, the illumination upon it will be the ratio of the luminous intensity to the square of the distance between source and surface, multiplied by the cosine of the a gle made by the surface with the normal p'ane. (This angle will always be less than 90 degrees.)

The formula is as follows:

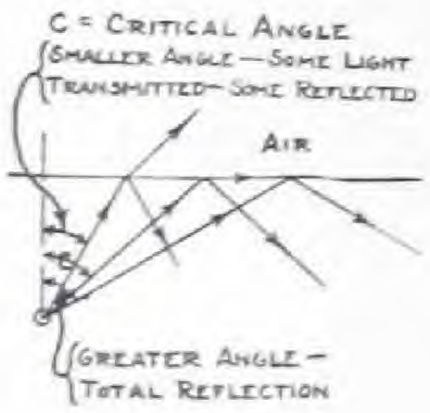
$$E = \frac{c.p.}{d^2} \times \cos A.$$

This formula is the basis of the *Point by Point Method* of calculating illumination.



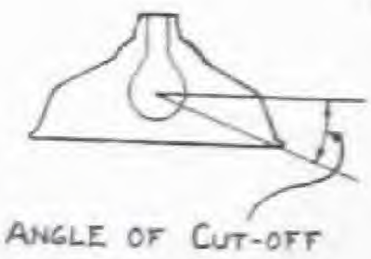
Cove Lighting

A system of indirect lighting in which lamps and reflectors are concealed by a molding or other suitable structural element around the edge of the area to be illuminated. The light is directed to the ceiling, from which it is diffusely reflected.



Critical Angle

A ray of light passing from a denser to a lighter medium, as from water to air, undergoes a change of direction, the amount of bending being governed by the ratio of the densities of the two media. If the ray, upon striking the surface of the water, makes an angle with a perpendicular to the surface less than 48 degrees 30 minutes it will emerge and pass off into the air. Should the ray make an angle with the perpendicular of exactly 48 degrees 30 minutes, it will not emerge but will be reflected along the surface of the water. This is known as the critical angle of the two media under consideration. At any angle greater than the critical angle the ray will be totally reflected at the surface of the water.

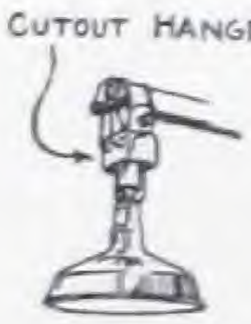


Cross Lighting

Lighting directed from two or more locations in order to illuminate objects from different sides and break up the sharp shadows which result when the light comes from one predominant direction, and which are often objectionable due to their distortion of the appearance of objects. Cross lighting is an important consideration in the floodlighting of buildings and other structures.

Cut-off

The angle above which the upward (in the case of a direct lighting unit) or downward (in the case of an indirect lighting unit) light is cut off and reflected so as to augment the unintercepted flux.



Cutout Hanger

A special hanger for a lighting unit which not only disconnects it from the mechanical support but also breaks the electric circuit, so that the fixture can be lowered for cleaning or lamp replacement. Such a device facilitates access to units which are hung high, as in an armory or foundry.

Daylight Lamp

An incandescent lamp having a blue glass bulb of special composition to obtain light approaching daylight quality. The daylight lamp is an economical means of obtaining general illumination of a whitish appearance. *Daylight Mazda lamps*, while well suited for their purpose of general illumination, are not recommended for color matching.

Daylight Lamp Signal

A signal in which the indication is obtained by means of a lamp equipped with a lens or reflector designed to give a beam sufficiently intense to be a useful signal at considerable distances in daylight.

Degrees Absolute or Degrees Kelvin

In many scientific measurements temperatures are measured from absolute zero(−273.1°C. or 491.6°F.). When measuring the high temperatures of incandescent lamps the results are usually expressed in degrees absolute or degrees kelvin (K) which corresponds to C° +273.1.

Depreciation

The gradual diminution of light output due to the blackening of lamps, accumulation of dust and dirt on lighting equipment, deterioration of reflecting surfaces and reflectors, etc.

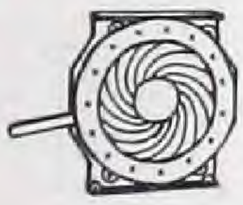
Inherent Depreciation is the depreciation due to ageing of the lamp; *Acquired Depreciation* is that due to dirt accumulations.

Design Volts

That particular voltage at which a lamp will meet its specifications for amperes, life, candlepower, etc. For certain classes of service where lamps are supplied from a battery, as in automobile lighting, and for special reasons, such as considerable variation of the supply voltage, lamps are designed for a certain voltage which has been determined to be the average of the range in voltage usually found in that class of service, the lamps giving satisfactory service if operated on the range of voltage which is marked on them.

Diaphragm

IRIS DIAPHRAGM

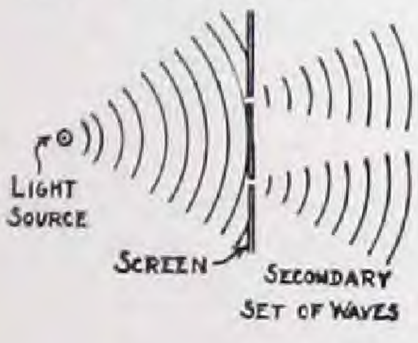


An opaque plate containing an aperture of certain shape or size for the purpose of permitting the passage of only such light as may be desired.

The *iris diaphragm* commonly used in camera and stereopticon work is made up of several adjustable sectors which gradually increase or decrease the size of the opening.

Diffraction

DIFFRACTION OF LIGHT WAVES THRU NARROW SLITS



A bending of light rays which occurs when light passes the edge of a body in which the thickness of the edge is smaller than the length of the light wave. The term is also applied to a spreading of rays when a beam of light passes through a very narrow aperture or opening in a screen. By ruling very fine lines (many thousands to the inch) on a mirror, it is possible by diffraction to set up interference so as to produce a spectrum similar to the prismatic spectrum, except that the long waves (for example, red, etc.) are proportionately spread out as regards the short waves (blue, etc.). Such a device is known as a *Diffraction Grating*, and the spectrum produced is called a *Diffraction Spectrum*.

Diffusion

The scattering of light rays so that they travel in different cross directions rather than in parallel or radiating lines. Sunlight, in passing through the earth's atmosphere, is more or less diffused by the particles of dust and moisture, so that the entire sky appears to be a source of light and the light

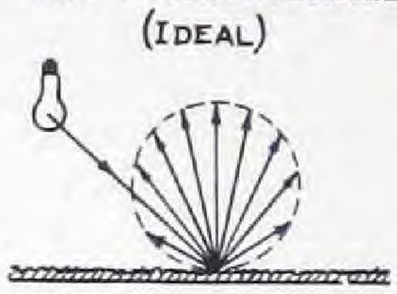
from the sky, entering a window, is spread throughout the room without striations, strong contrasts, or dense shadows. This sort of an effect is known as *Diffuse*, or *Diffused, Illumination*. Due to the cross light the shadows are luminous, soft, and free from harshness, while, because of the large size of the source, a considerable amount of light may be received without the source appearing bright enough to produce objectionable glare.

Artificial lighting may be rendered *Diffuse* by various means, of which the following are some of the more important:

Diffusing Bulb, in which a frosting or coating makes the lamp bulb translucent, so the light appears to come from its entire area, masking the high brilliancy of the fi'ament.

The use of several diffusing bulbs in place of a single one of higher power increases the degree of diffusion.

DIFFUSE REFLECTION FROM ROUGH MAT SURFACE (IDEAL)



Diffusing Globe in which opalescent glass or roughened glass is interposed between the filament and the eye so as to make the entire globe appear luminous, with corresponding softness of shadows. Since globes are larger than lamp bulbs, they usually produce a higher degree of diffusion.

Diffusing Reflector, in which the reflecting surface is roughened or made of translucent enamel so as to act as a large secondary light source of low brightness. This type of reflection is known as *Diffuse Reflection*. With indirect and semi-indirect lighting, a dull white ceiling becomes a very effective diffusing reflector.

Either too little or too much diffusion should be avoided. The former produces glare, striations, and harsh, dense shadows; the latter makes rounded surfaces and relief appear flat so that it is difficult to see the contour of moulding. Such an effect is referred to as "Flat Lighting."

DIMMERS

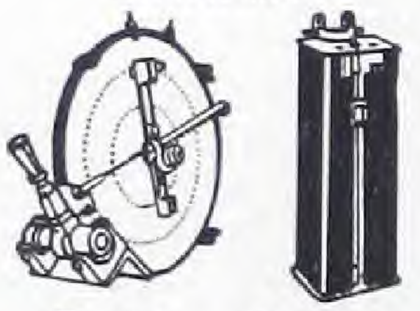


PLATE PORTABLE

Dimmer

A variable resistance connected in series with incandescent lamps to reduce the brightness or the light output to a desired value. The "steps" in a dimmer should be so proportioned as to cause a steady rather than a jerky increase or decrease in the illumination. Several circuits may be dimmed in unison by interlocking the individual dimmer levers.

Dipped Lamp

A lamp the emitted light of which is colored by passing through a thin translucent layer produced by dipping the bulb in a solution. This solution generally consists of organic dyes dissolved in a quick-drying medium such as amyl acetate.

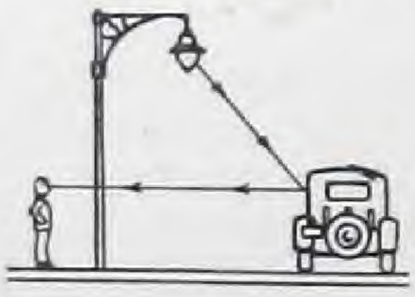
DIRECT LIGHTING UNIT

Direct-lighting Unit

A lighting unit which emits the major portion of its flux in such a manner that it reaches the area to be illuminated without redirection or reflection.

Examples of direct-lighting units are incandescent lamps (either with clear or with diffusing bulbs), enclosing globe units, R.L.M. and Glassteel units, ordinary types of portable lamps, etc.

DIRECT VISION



Direct Vision

The seeing of an object by means of light reflected by the object to one's eye. This is the ordinary method of vision in the daytime or in illuminated interiors. (*See Silhouette Vision.*)

Dispersion

The separation of light by means of a prism into its component colors, due to the different degrees of bending exerted by the prism upon the individual colors. (*For illustration see Prism.*)

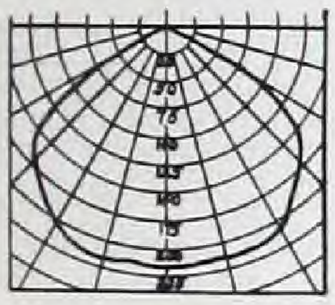
Display Lighting

The floodlighting of buildings or the outlining of them with incandescent lamps, etc.

Distribution of Illumination

The disposition of illumination intensity throughout a room or other area. Such a characteristic is recorded in *Illumination Curves.* (*See Foot-candle.*)

CANDLE-POWER DISTRIBUTION CURVE OF A DEEP-BOWL STEEL REFLECTOR



Distribution of Light

The manner in which a light source or lighting unit emits its flux in various directions. The characteristic of light distribution is commonly recorded in the *Candlepower Distribution Curve.* (*See Candle.*)

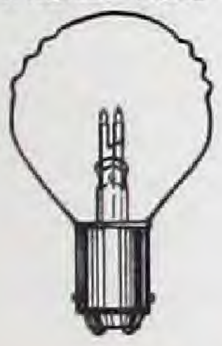
District Brightness

A term used to express brightness of the surroundings of a sign. Times Square in New York City is usually assigned a value of one, and an isolated district with no street or store window lights, ten. Other districts would be given values between these.

Dome Reflector

A reflector resembling in shape an inverted saucer. Very shallow dome reflectors were very extensively used with low power lamps, but since the advent of the MAZDA C lamps there has been a tendency toward deepening the domes, as exemplified in the *R.L.M. Standard Dome Reflectors,* q. v., so as to afford eye protection. (*For illustration see R.L.M. Standard Dome.*)

DOUBLE FILAMENT AUTOMOBILE HEAD LAMP



Double Filament Lamp

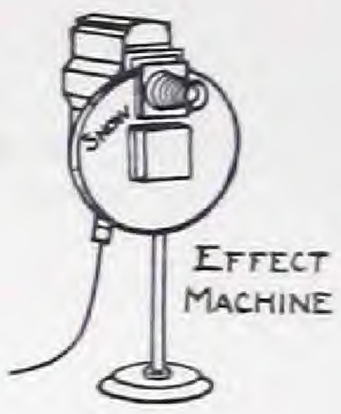
A lamp having two independent operable filaments mounted in the same bulb for a special purpose. For example, in certain automobile headlights one filament may be above the focal point of the reflector and the other filament below it, to give a different distribution of light on the roadway.

Downward Flux

All or part of the light flux emitted from a lighting unit over angles below the horizontal. It is commonly taken to mean all the light flux throughout this range of 90 degrees from the nadir to the horizontal. (*For illustration see Upward Flux.*)

Effective Lumens

That light, measured in lumens, which is useful in providing the desired illumination. It is commonly taken as being the product of the area illuminated and the intensity of illumination. Thus an area of 1000 square feet illuminated to an intensity of 5 foot-candles would require 5000 *effective lumens.*

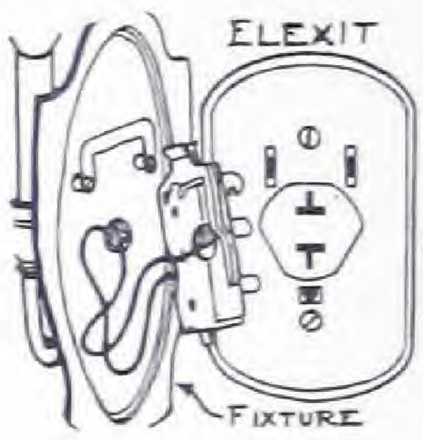


Effect Machine

In stage lighting, a spot lamp fitted with a second condensing lens and objective lens, becoming in fact a large stereopticon. If at the point where the lantern slide is usually inserted the proper type of "effect head" is placed, the appearance of clouds, rippling water, falling snow, etc., is produced on the scene. Sometimes known as a "*sciopticon.*"

Efficiency of a Source

Efficiency of the lamp or lighting unit is commonly expressed by the ratio of the total luminous flux (light) to the total power consumed. In the case of the incandescent lamp it is expressed in *lumens per watt.* This practice has generally superseded the former one of using the ratio of *watts per candle* (mean spherical or mean horizontal). When resistance, reactance, or other power consuming accessory is used with the lamp, the statement of efficiency should indicate whether or not the wattage consumed by the accessory is included. In the case of a lamp depending upon combustion, efficiency may be expressed in lumens per thermal unit consumed per unit of time. For example, "*Lumens per British Thermal Unit consumed per hour.*"

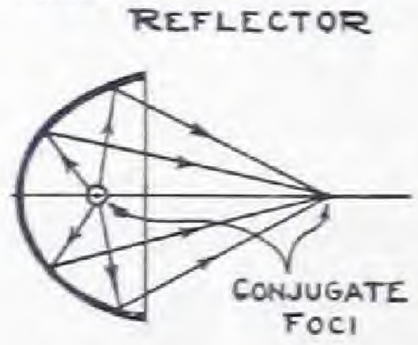


Elexit

A special receptacle, supported from an electric outlet box and constructed in such a manner as to permit of the rapid exchange of lighting fixtures at that outlet. In appearance, it is somewhat similar to a flush receptacle of the baseboard type and its operation is along the same general lines.

Ellipsoidal Reflector

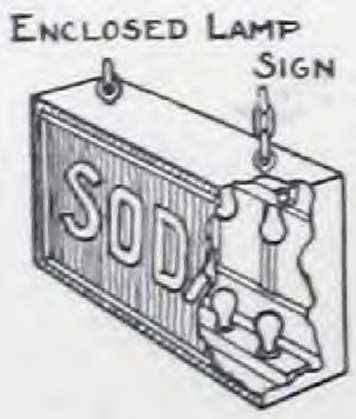
A reflector having an elliptic section parallel to its axis which lies in a horizontal plane, and a circular section in any plane at right angles to the axis. In other words, a prolate ellipsoid of revolution. Such a reflector has two focal points located on the axis, which, in a sense, can be said to be conjugate, since, if a light source is placed at either, an image of it will be formed at the other.



Because of the large collecting angle of such a reflector, many persons are misled into believing that the image of a source formed at one of the focal points will be brighter than the source itself. This is a fallacy, since the image is a composite of all the individual images formed by each point on the surface of the mirror and these individual images all vary in size, those reflector points nearest the source forming the smallest. The final image is, therefore, much larger than the original source, so that no increase in brightness is obtained.

Emanation

The effluence of minute particles, or of a gaseous substance, from a body, as radium emanation. Sometimes used to describe the emission of light from sources.



Emission

The sending out, or the release of radiation. (*See Cosine Law of Emission.*)

Enclosed Lamp Signs

Signs in which the incandescent lamps are enclosed inside of the sign iself. The light escapes through translucent letters of different types.

ENCLOSING UNIT

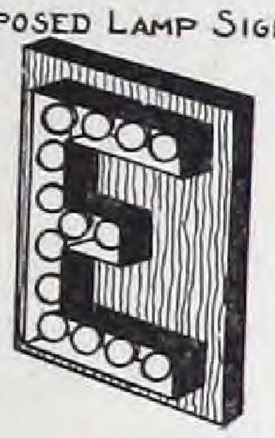
Enclosing Unit

In the ordinary use of the term, a direct-lighting unit in the form of a diffusing globe entirely surrounding the light source.

Etching

The marking of a lamp in some distinguishing manner by acid or sand etching, or other method.

EXPOSED LAMP SIGN



Exposed Lamp Signs

Signs in which incandescent lamps are set in the face of a letter and not covered by any portion of the sign, e.g., trough letter signs.

Extended Source

A light source having dimensions too large to permit of its being considered as a so-called point source.

In optics, the old conception of a light source was based upon the assumption of a source which had no dimension, i.e., a point. This idea prevails in physics textbooks even today. While purely theoretical, it is a convenient means of explaining the action of lenses and mirrors.

The practical idea of a light source is one which recognizes the fact that all sources have appreciable area. In other words, instead of being a point, they are extended areas, and must be so considered in practical optics.

Extensive Distribution

The characteristic distribution of lighting units which emit the major part of their flux over a comparatively wide angle (about 60 degrees each side of the nadir), as distinguished from those giving a still wider spread of light known as distributing, and those concentrating the light somewhat more, known as intensive.

Fechner's Fraction

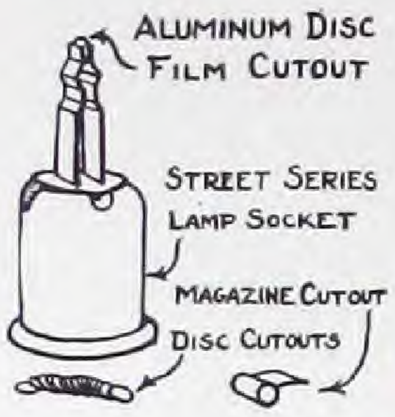
The minimum difference in brightness which the eye can recognize, expressed as a percentage or fraction. Its numerical value for the average eye and ordinary intensities of illumination is about 0.01. If two adjacent surfaces (of the same color) have a difference in brightness of less than one per cent they will appear as a single surface (*See Brightness Contrast.*)

Field of View

The entire area in which objects are visible with the eye still fixed at some definite point. The visual field for a single eye extends from the visual axis outward (away from the nose) about 90 degrees, upward 50 degrees, inward 60 degrees, and downward 70 degrees. Within these limits light and form can be recognized to a variable extent. For color perception the area is less extensive and unequal for different colors. Blue has the largest field next to white, green the smallest field of all, and red occupies an intermediate position.

Filament

A conductively continuous light giving element which becomes incandescent due to its resistance to passage of current through it. In the MAZDA lamp it is made of drawn tungsten wire, usually coiled, in various shapes and sizes. depending upon the service. (*For illustration see Coiled Filament.*)



Film Cutout

A protective device used in series circuits, generally placed across the lamp terminals. When the lamp burns out, an insulating film is punctured, due to the high voltage, and the electrical continuity is restored.

Fitter

A metal cap which forms a part of certain fixtures and is used to hold the glassware, such as the enclosing globe, in place. The term is also used in specifying the dimensions of a glass globe or reflector, indicating the approximate size of opening. Thus we have 4-in., 6-in., 8-in., etc., fitters. (*For illustration see Enclosing Unit.*)

Fixture

Essentially a lamp-holding device, which has been developed by gradual stages to include elements to reflect, diffuse, or otherwise distribute the light from the lamp over the area to be illuminated, and to shield the eye from the bright filament. In residences, it is often used simply as an ornamental holder for the lamp.

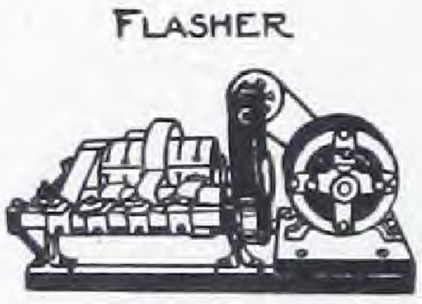
Flame Tint

The color designation of a lamp which has such a coating that it emits light of approximately the color of the kerosene oil lamp flame.

Flare

In aviation or marine lighting a blaze of fire or light, usually brief, used as a signal. Flares are also used for the purpose of finding a safe landing place for an airplane in an emergency.

Flasher



A mechanical device for opening and closing repeatedly an electrical circuit in which are connected incandescent lamps. Three principal forms are available: (a) for carrying the relatively heavy currents of electric signs, a motor-driven drum on which are mounted curved copper segments; (b) for flashing a single lamp, a wound resistance thermal device attached to a socket or receptacle; (c) for flashing electric street beacons, a motor-driven mercury switch which tilts back and forth.

Flashing

The process, during lamp manufacture, of applying a higher voltage than normal to the lamp, in order that certain chemical reactions for perfecting the vacuum may occur.

Flicker

When light, reflected from an object or emitted by a source, is periodically interrupted, as by means of a revolving sectored disc, the intensity of light reaching the eye will be lowered to an amount proportional to the ratio of the total area of the openings to the total area of the disc. This is equivalent to saying that removing all of the light part of the time is equal to removing part of the light all of the time.

The interruptions to the passage of light so produced may be evidenced in the form of *flicker*, the various factors which determine whether *flicker* will be produced being as follows: the color of the object viewed by this light, and the degree of

variation in the intensity of light (whether from maximum to zero, or from maximum to some level of intensity higher than zero).

The frequency of the cut-offs per second at which the sensation of flicker disappears is referred to as the "*vanishing flicker frequency.*" The vanishing-flicker frequency for any set of conditions can be expressed as a logarithmic formula in which are involved the factors mentioned above.

The worst possible condition of *flicker*—the alternate masking and unmasking of a bright light source, such as an incandescent lamp—has a vanishing-flicker frequency of 66 cycles per second.

The flickering of low wattage incandescent lamps on low frequency alternating-current circuits is somewhat akin to that produced by the sectored disc, save that at no time is the light completely cut off. The flicker is due to the cooling of the filament as the current goes through zero in the alternations. Thick filaments retain their temperature better, as they have more "body." As a general rule no flicker is noticeable with any MAZDA lamp on sixty cycles. On twenty-five cycles it is not particularly noticeable on lamps above 50 watts on 115-volt circuits.

Because of its effect on the eyes, prolonged vision under flickering illumination, or even short periods under pronounced flicker, or extremes in intensity should be carefully avoided.

Floodlight

FLOODLIGHT

A device for projecting a wide beam of light in one general direction, usually by means of a parabolic reflector. A floodlight gives a wider beam than a searchlight but a narrower spread than an angle reflector. Glass doors are generally used to exclude dirt and moisture. and sometimes to diffuse or otherwise modify the beam. Floodlights are employed for floodlighting signs, statuary, building faces, foliage, outdoor stages, railroad and factory yards, etc. They are ordinarily placed at a distance of from 20 to 500 feet from the object to be lighted. Different types give various beam widths, ranging from 10 degrees to 90 degrees. Reflector diameters range from 10 to 28 inches, and wattages from 250 to 1500. Some types employ standard MAZDA C lamps, though the narrow angle types employ the MAZDA C floodlighting lamps which have concentrated filaments. Either mirrored glass or metal reflectors are used, the former being generally considered better.

On the stage, a high wattage light source in an open reflector on an adjustable portable stand to direct a flood of light where needed. Usually equipped with gelatin color medium. Also known as *Open Box* or *Olivette* light.

Fluorescence

Light due to transformation into visible radiant energy of invisible radiant energy, such as ultra-violet.

Light which is of a wavelength too short to excite vision as for instance, ultra-violet, falling upon certain surfaces such as calcium tungstate or calcium sulphide, undergoes a transformation to another wavelength in the visible spectrum when passed through certain substances, such as quinine and aesculin. Substances which exhibit this property are said to be *fluorescent*, a name derived from fluor spar, which possesses it to a remarkable degree.

Flux

In practice it is common and convenient to conceive of light given out by an illuminant, or the illumination received on a surface, as a static quantity corresponding to quarts of water, barrels of wheat, cubic feet of sand, etc. Strictly speaking, however, light is a flow of energy corresponding to a watt in electrical parlance, quarts of water per second, etc. A constant sensation of light is produced by a continuous flow of light energy. The physicists sometimes measure this flow or *flux* of radiation in ergs per second. This of course refers to the energy and is independent of visibility. It might be applied to invisible radiation. Illuminating engineering more particularly concerns itself with the visual effect of light *flux*, and so measures it in terms of visual sensation. For this the unit is the *Lumen* (q. v.). In this case *flux* may be considered as an intensity times the area over which it is distributed (e.g., candles x unit of solid angle or foot-candles x square feet).

Flux of Light Method

A quick, and reasonably accurate, method of making illumination calculations based on the flux which remains after the losses resulting from the absorption of light by walls, ceilings, reflectors, etc., are subtracted from the total flux generated by the lamps. All of the remaining flux is assumed to be effective on a horizontal plane 30 in. above floor level, at which elevation work is generally assumed to be carried on. If the actual working plane differs appreciably in location from that assumed, the calculations, for greater accuracy, must be revised to take this into account.

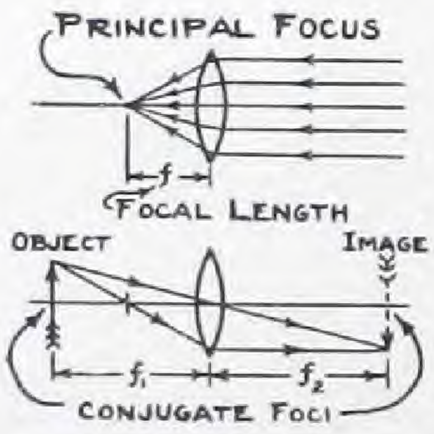
The *flux of light method* has, except in very special cases, replaced the older, more tedious *point by point method* (q. v.).

The general *flux of light* formula, which makes use of several predetermined constants, is as follows:

$$\text{Total lumens (of lamps)} = \frac{\text{Effective Lumens}}{\text{Depreciation Factor} \times \text{Utilization Constant}}$$

Focus

The adjustment of the elements of an optical system for the production of an image or a desired distribution of light. It is applied in connection with lenses or concave reflectors.



Lenses: For measuring the *Focal Length* of a lens it is common to utilize the direct rays of light from the sun, which, as received at the earth, are practically parallel. If a converging (convex) lens is placed in a direct line between the sun and a screen, it is possible to find a position on which the image of the sun will be formed upon the screen. (Such an image will ignite most ordinary materials.) The point where this image is formed is known as the *Focus* or *Principal Focus*, of the lens, and the distance from the optical center of the lens to the image is known as the *Focal Length*. This distance is used in describing the refracting power of the lens. Conversely, if a concentrated light source is placed at the focal point, light transmitted by the lens will be bent into approximately parallel rays, the approximation depending upon the degree with which the dimensions of the source approach zero (the dimensions of a point). Similar phenomena occur with a combination of lenses having a converging character, and the same terms are used for the combination

as for a single lens. If a light source or an illuminated object be placed at some point beyond the principal focus, it is possible to form an image on a screen set at proper distance. A pair of such *focal points* are known as *Conjugate Foci*. There are an infinite number of such *Conjugate Foci* for any lens.

Their distances are expressed by the formula: $\frac{1}{f_1} - \frac{1}{f_2} = \frac{1}{f}$, where f is the principal focus and f_1 and f_2 the conjugate foci. If a beam of sunlight falls on a diverging (concave) lens, it will be spread rather than condensed, so that the rays appear to radiate from a point in front of the lens. This point is known as the *Virtual Focus*. and its distance from the optical center of the lens is the focal center or the lens.

These diverging lenses are sometimes considered as having negative focal lengths.

Mirrors: A beam of light from the sun falling parallel to the axis on a concave parabolic mirror will be reflected to a *Focus* at a point known as the *Focal Point* of the reflector. The distance along the axis from this *Focal Point* to the mirror is known as the *Focal Length* of the mirror. Conversely, light from a concentrated source located at the focal point of the mirror will be reflected in rays approximately parallel to the axis.

While a spherical mirror does not have as accurately defined a focus as does the parabolic mirror, the same nomenclature is sometimes used.

The above terms are used in connection with stereopticons, motion picture projectors, spot lights, searchlights, floodlights, etc.

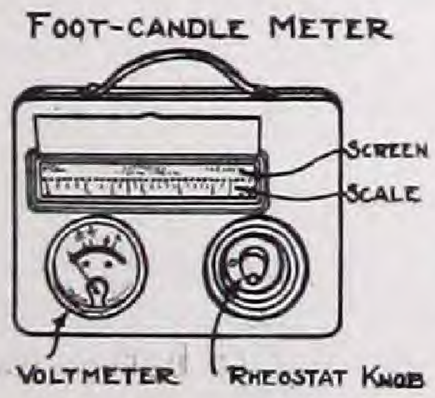
Focusing Distribution

The characteristic distribution of light units which emit the major part of their flux over a narrow angle (about 15 degrees each side of the nadir) as distinguished from those giving a wider spread of light known as intensive, and those concentrating the light somewhat more, known as concentrated.

Foot-candle

The unit of illumination, with the English units as a basis. It is defined as the illumination at a point one foot from a source emitting one candle power in the direction of the surface. It is the illumination received when one lumen of light falls on one square foot of area. A fair idea of the illumination represented by one foot-candle can be obtained by holding a piece of paper one foot away in a horizontal direction from an ordinary wax candle, or about five feet away from an ordinary 25-watt (that is, 25-candle) lamp.

1 Foot-candle = 10.76 Lux (International) = 11.95 Meter-Hefners



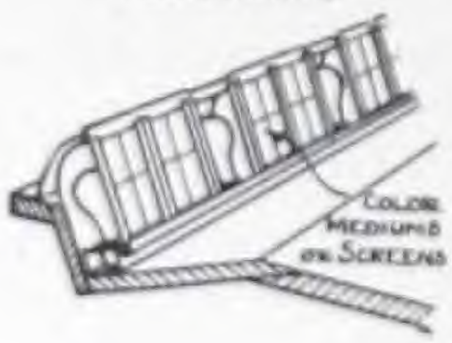
Foot-candle Meter

A small, compact illumination photometer, with a fair degree of accuracy, about 6 in. by 8 in. in size, weighing 3 lbs , having a range of from 0.012 to 100 foot-candles. Its principal advantage is found in its ready portability, which permits taking readings quickly, and directly in foot-candles, on the workbench, desk, etc. Its simplicity of construction and of operation make it especially desirable for inexperienced persons.

Foot Lambert

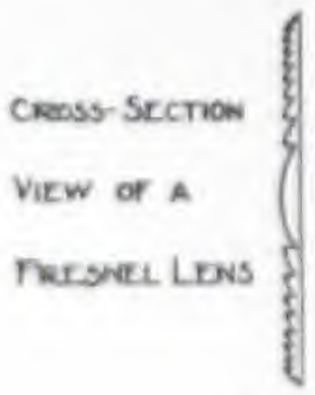
The average brightness of any surface, or the uniform brightness of a perfectly diffusing surface, emitting or reflecting one lumen per square foot. A completely reflecting surface under an illumination of one foot-candle, therefore, has an average brightness of one foot lambert; the average brightness of any surface in foot lamberts is the product of the illumination in foot-candles by the reflection factor of the surface. The foot lambert is only one of several ways in which the brightness of sources or objects may be expressed. (*See Brightness.*)

FOOTLIGHTS



Footlight

A row of lamps, generally clear and colored (or equipped with color media), on several circuits, with a reflector to direct the light upward and to the rear, located at the very front edge of the stage, or of the show window.



Fresnel Lens

A type of lens, designed by Fresnel, having the characteristics of a plano-convex lens. It produces a sheet of light parallel to the horizon and is widely used for lighthouses and other beacons.

Gas-filled Lamps

An incandescent lamp filled with inert gas, such as argon with a small amount of nitrogen, at a substantial pressure, and having a filament of large effective diameter which may be operated during a long useful life at a temperature and at an efficiency higher than would be permissible to give the same useful life if the same filament were operated in a vacuum.

In a gas filled lamp a closely coiled filament of small wire has to a considerable extent the advantages of a large filament.

Gas filled lamps are known as *MAZDA C-lamps* to distinguish them from *vacuum*, or *MAZDA B lamps*. The gas-filled construction is commonly used in sizes of lamps where the gain in light emission more than compensates for the convection loss introduced by the gas. (*For illustration see Light Center Length.*)

Gauge Light

A small lamp used to illuminate the face of air, steam or other types of gauges or meters in locomotives, boiler houses, etc.

General Overhead Lighting

A system of overhead light sources or luminaires usually symmetrically arranged to produce approximately uniform illumination throughout a room or area. If properly designed, this lighting makes possible equally good vision in any location or position, as is the case in well distributed daylight.

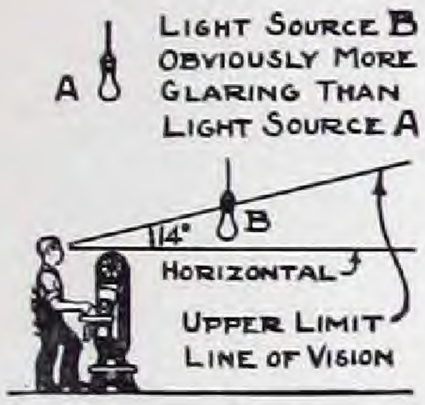
Getters

Chemical substances introduced in the incandescent lamp bulb to improve the vacuum during the process of manufacture, in the case of the MAZDA B lamps; and to better the lumen maintenance of MAZDA lamps during life.

Glare

A sensation of discomfort or interference with vision which results when (a) one looks directly at a light source or an otherwise extremely bright surface, so that central vision is affected directly, peripheral vision indirectly, and the eye is accommodated to the distance of the glaring light; (b) the eye is fixed on some object of interest, probably at reading distance, and the light from the glaring source or intruding bright surface forms an angle with the visual axis so that peripheral vision is affected directly, central vision indirectly, but the eye is not accommodated to the distance of the glaring light.

Glare is a sensation and therefore subjective, being variable with the individual and difficult to measure. It is dependent on a number of conditions as follows:



High brightness of source
High contrast between source and background
Location in field of view
Total volume of light entering eye
Time of exposure.

High brightness light sources cause glare when viewed even casually. A glance at the sun or an unshielded gas-filled incandescent lamp is sufficient to prove this statement. Objects of low brightness, not necessarily primary light sources, can also be glaring when viewed for a continued length of time. For example, an overcast sky may be quite glaring.

If a decided *contrast* in brightness exists between the light source and its surroundings, the eye will be unable to accommodate itself to the two degrees of brightness. A lamp seen against a dark surface illustrates this case.

Tolerance of bright light sources in the immediate vicinity is made possible by their being located at such a height as to place them above the ordinary range of vision, which general agreement fixes as being 14 degrees above the horizontal. The size of the light source in proportion to its distance from the observer has an important bearing on the possibility of glare, since a 100-watt lamp in an opal glass globe can cause as much discomfort, if placed near the observer, as a bare lamp located farther away.

Glint

The specular reflection of light from polished or wet surfaces, in which the image of the source is evident. In certain phases of illumination the identification of objects and their location is materially assisted by the presence of glint. (See *Regular Reflection.*)

Globe

A specially shaped piece of glassware which is used to enclose an incandescent lamp in order to diffuse and distribute the light coming from it. In combination with the lamp and a suitable suspension, it forms a complete lighting unit. Clear globes, although not having the properties described above, are often used to afford protection from the weather, and to exclude explosive dust or gases. (*For illustration see Enclosing Unit and White Way Lighting.*)

Gloss

A smooth finish imparted to a surface which tends to make it reflect light in a specular manner.

Group Lighting

(*See Localized Overhead Lighting.*)

Halation

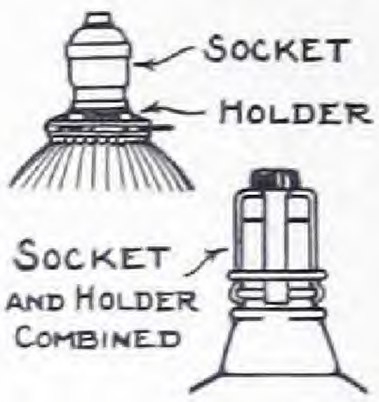
The halo effect seen around light sources which causes the outlines of the letters in a sign to appear blurred.

Hanging Height

The height at which lighting units are suspended above the floor level, or working plane, whichever is considered when designing the system.

Headlight

A form of projector used to concentrate light into a beam and project it ahead of moving vehicles, such as automobiles, locomotives, street cars, etc.



Holder

A mechanical device for supporting a piece of lighting glassware or a metal reflector in its proper position with respect to an incandescent lamp.

Hue

That property of color by which the various spectral regions are characteristically distinguished. All colors except purples and white may be matched in hue with spectral colors. In the case of a purple, the spectral hue complementary to the hue of the purple is ordinarily used for scientific designation.

Illumination

In general, the visual sensation produced when radiant flux within the limits of wavelength of so-called visible light, of sufficient intensity and duration, impinges on the retina. It is often used synonymously with the term lighting. Specifically, illumination is sometimes used to designate visible radiation falling on a surface as distinguished from light emitted from a source. Its quantitative unit is the foot-candle.

Illuminometer

A synonym for *portable photometer*.

Illusion

The deceptive appearance which objects, under certain conditions, present to the eye. Physicians separate these phenomena into normal illusions and pathological illusions, the latter often being an indication of insanity in the person experiencing them. It is possible to establish optical illusions by lighting an object or group of objects in a certain manner, so as to create a false perspective.

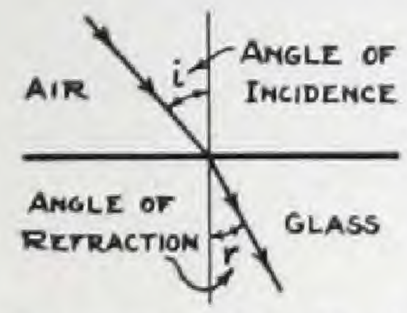
Incandescence

If the temperature of an electric conductor is raised to a point where it glows and emits visible radiation, that conductor is said to be incandescent. This is what occurs with the filament in a lamp. The rate of emission of light and its color composition will depend upon the operating temperature of

the filament. As the current density, and hence temperature, is increased, the candlepower of the emitted light will increase and the dominant color of the light will shift from the red end of the spectrum toward the blue. This will be further attended by increased efficiency in the rate of emission; that is, relatively more light per unit of electrical energy will be given off, but the life of the lamp will be reduced.

Index of Refraction

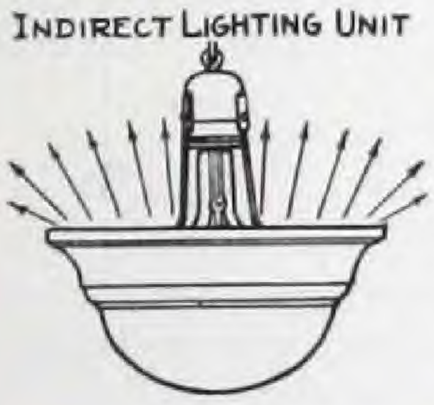
Light, upon leaving one medium of given density and entering another of greater or lesser density, suffers a change in its speed of propogation. If the entered medium is the denser, the speed will be reduced, whereas if this medium is of lesser density, the speed will be increased.



The change in speed is always accompanied by a change in direction of travel (see *Critical Angle*), except where the light falls normally or perpendicularly, being in effect a bending of the light from its original path at the point of entrance into the second medium. The degree of bending depends upon the relative densities of the two substances through which the light is traveling, being greater for large differences in density than for small.

It is obvious that a ray of light leaving one medium and entering another will, therefore, make two angles with a perpendicular to the point where this ray changes from one medium to the other, the angle in the lighter medium being greater than that in the denser. The *ratio of the sines* of these *two angles* is called the *index of refraction*, and this ratio is constant for the same two media.

If one of the media is a vacuum, the ratio is called an *absolute index*, the ratio of two absolute indices being, of course, a *relative index*.



Indirect-lighting Unit

A lighting unit which emits practically all of the light flux upward to the ceiling for diffuse reflection over the room area.

The ceiling, or its equivalent, then becomes a secondary source of low brightness and large area, so this system is particularly favorable for providing even illumination of a diffuse nature and free from glare, since no very bright areas or sources are visible.

In Focus

When a lens system used for projecting picture images onto a screen is properly adjusted so that the image on the screen is as clearly and sharply defined as that system will permit, the picture is said to be *in focus*.

When auto headlamps are in such a position in the parabolic reflector as to give the smallest spot of illumination they are *in focus*.

Infra Red

Radiation of a longer wavelength than that of visible radiation, but adjoining it. This is evidenced as radiant heat. A large part of the total radiation from most light sources is in the *infra red*.

Inside Frost

An etching chemically applied to the inside surface of incandescent lamp bulbs. This practice has a number of

advantages: It gives a certain degree of diffusion; it leaves the outside surface of the bulb smooth so that it does not readily gather dust and dirt, and it results in the loss of very little light (only about two per cent). With inside frosting the lumen maintenance is better than for the same lamp with outside frost. Obviously, such inside frosted lamps are less glaring than those with clear bulbs.

Intensity

The power of light emitted in any given direction. It is measured in *candles* or *apparent candles*.

Intensive Distribution

The characteristic distribution of lighting units which emit the major part of their flux in a comparatively narrow angle (about twenty degrees each side of the nadir) as distinguished from those giving a wider spread of light, known as extensive and distributing, and those concentrating the light more strongly, known as focusing.

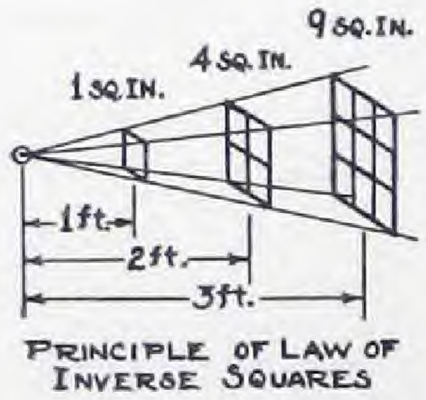
Interference

If two clean pieces of plate glass are strongly pressed together, bands of color appear between them, due to wave interference of the light in the air-film separating their surfaces. The rays reflected from the lower surface of the upper glass meet those reflected from the upper surface of the lower glass, and, since the path of the latter is the longer, they are in the condition of complete interference when this difference in path is equal to half a wavelength for the light used. If white light is used, bands of color will be seen, whereas if monochromatic light is used, light and dark bands of the same color will be seen. The iridescence of certain kinds of glass, of thin films of oil upon water, of soap-bubbles, of insects' wings, and of cracks in thick glass are commonly-observed examples of light interference.

Intrinsic Brilliancy

The brightness or brilliancy of a light source or surface expressed in intensity emitted or reflected per unit of projected area. Various units of measurement are employed in this connection; e.g., candles per square inch, candles per square centimeter, etc. (*See Brightness.*)

Inverse Square Law



PRINCIPLE OF LAW OF INVERSE SQUARES

A general geometric principle applying to light, magnetism, and other effects which radiate out from a central point and so become attenuated through being spread over greater space as the distance from the point increases. In illuminating engineering this law assumes a source of light of sufficiently small dimensions as to be considered a *point source*. For ordinary calculations, this condition is assured if the distance from the source to the point of measurement is at least five times the maximum diameter of the source. The accuracy is greater if this factor is larger. If we had a screen, with an opening 1 inch square cut in it, placed one foot from an incandescent lamp, it is obvious that the light passing through this opening and falling on a second screen at 2 feet from the light source would give a spot 2 inches square, or 4 square inches; at 3 feet, 3 inches square, or 9 square inches, etc. In other words, as the beam travels away from the lamp it is

spread over an area which increases with the square of the distance. Obviously, the same flux spread over a larger area correspondingly reduces the illumination.

The *Law of Inverse Squares* does not take into account any absorption of light by the atmosphere, smoke, or any other medium. It does not apply to parallel light nor to light sources of large dimensions, as can be shown by repeating the above experiment.

This *Law of Inverse Squares* is made use of in photometry and in theoretical calculations. It was formerly used extensively in predicting the illumination provided by lighting installations, but, because of the arduous calculations involved and the difficulty in evaluating the light added by reflection from ceiling and walls, it has given way for such purposes to the simpler *Flux of Light* method, q. v.

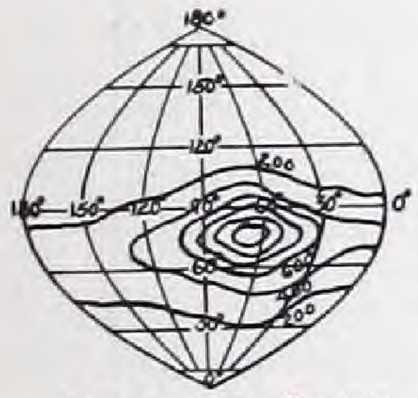
Inverse Square Region

The region within which a beam of light follows the inverse square law.

The use of lenses and mirrors under certain conditions renders the inverse square law inoperative as regards the beam generally. In the case of a lens or mirror focused with respect to the light source so that a beam of approximately parallel rays results, the intensity at a point of appreciable distance from the projector in question will follow the inverse square law. The point at which this law becomes practical will be dependent on the diameter of the mirror, its focal length, the size of the source, etc. With automobile headlights, for example, 50 ft. from the source is the beginning of the inverse square region; for larger headlights and floodlights, 150 ft.; and for large searchlights, 1000 or 2000 ft.

Irradiation

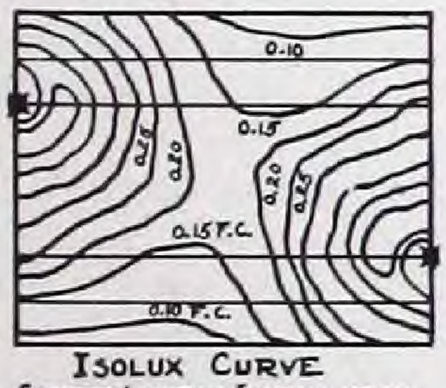
The apparent increase in size of a light source as one moves farther away from it.



ISOCANDLE CURVE

Isocandle

The candlepower distribution from a lighting unit, over all angles, can be plotted upon a special chart representing a sphere on which points of equal candlepower value are jointed by a line (ordinarily irregular) which forms a closed loop in much the same fashion that a single line is used on topographic charts to trace adjacent points having the same elevation. Such a chart is called an *isocandle curve* and the lines joining all points of equal candlepower value are called *isocandle lines.*



ISOLUX CURVE
STREET LIGHTING INSTALLATION

Isolux

If points of equal illumination over a given area, drawn to scale, are connected by continuous lines, as is done on topographic, isobar, or isotherm charts, a graphic representation is given of the illumination conditions prevailing.

Lambert

The average brightness of any surface, or the uniform brightness of a perfectly diffusing surface, emitting or reflecting one lumen per square centimeter.

For most purposes the *millilambert* (0.001 lambert) is the preferable practical unit for evaluating the brightness of illuminated surfaces. (*See Brightness.*)

Lamp

The generic term applied to any light source and its operating mechanism.

As regards incandescent lamps, it refers to the finished product, comprising the bulb, filament, anchors, stem, lead-in wires, base, etc.

Lamphouse

A housing or container in which an incandescent lamp or other light source is placed for operation. In the case of an optic projector the lamphouse usually supports a condenser lens, a mirror (for an incandescent lamp), a lamp-holding mechanism, and control equipment for adjusting the lamp.

Landing Light

A light mounted on an airplane which illuminates the ground to facilitate landing.

Large Lamp

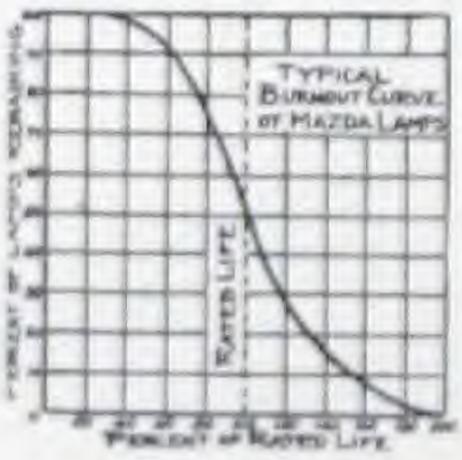
The division between large and miniature lamps is more or less arbitrary, being governed to a considerable extent by the use of the lamps and the natural channels of marketing. The *Large Lamp* class includes practically all types of lamps used on the circuits of utility companies, for steam and electric railway service, and country home lighting.

Lens

A specially formed piece of hard glass having one or both of its surfaces ground and polished to a spherical or parabolic shape (present practice makes use of but one parabolic surface in combination with a plane or spherical surface in this form of lens). Lenses are essentially image-forming devices and are used primarily for magnifying purposes and for collecting a large angle of light from a source and then redirecting it to form a beam or to bring it to a focus, depending upon the use intended. *(See Focus.)*

Life (of Lamp)

The number of burning hours for which a lamp is specifically designed. This life varies with the service, and for tungsten filament lamps bears a definite relation to the light output of the lamp. In general, it can be said that if the life is lengthened the light output will be decreased, and if the life is shortened, the light output will be increased.



The most economic life of a lamp is determined by considering the cost of the lamp, the cost of making renewals, and the cost of power per unit of light output consumed throughout life. Generally speaking, the cost of the lamp is a really small part of the total operating cost.

It is impossible to make all lamps of identical characteristics, therefore some will fail earlier than others. Figures given on lamp life do not apply to individual lamps, but represent the average value for a large group of lamps.

Lamp life is now usually expressed in terms of life to burnout; formerly it was often the life to 80 per cent of initial candlepower. This last expression means that the lamp is considered as having lived its useful life when its total light output drops to 80% of its initial value.

As the voltage at which a given lamp operates determines its filament temperature and hence its efficiency and life, it

is possible to predetermine the life of a lamp designed to give a certain life when operated at a particular voltage if this lamp were operated at some other voltage. These relative lives are represented by an exponential function of the ratio of the two voltages and the exponent which applies is known as the *Life Exponent*, or, more accurately, the life-efficiency exponent, which is the one generally used. This exponent depends upon the individual type and size of lamp and usually is between six and seven; that is, the life varies inversely as the sixth to seventh power of the efficiency. There are other life exponents (which are, however, not often used) that can be determined, such as life-voltage, life-candlepower, etc.

Life Test

The testing of a certain number of each type and size of lamps to observe their operating characteristics in order to insure satisfactory average performance. The lamps are burned until the filament fails.

Light

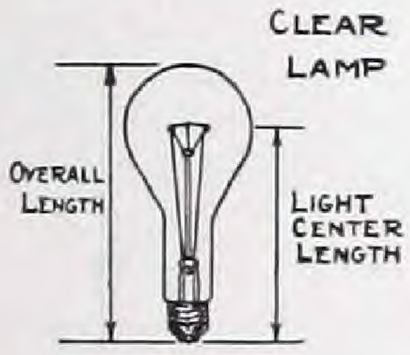
The term light is used in various ways:

(a) To express the visual sensation produced normally when radiant flux, within the proper limits of wavelength, of sufficient intensity and duration impinges on the retina.

(b) To denote the luminous flux which produces the sensation.

(c) Often in common parlance the word light is applied to wavelengths outside the visible spectrum (ultra-violet light). A better term is, of course, ultra-violet radiation.

Light Center Length



The distance from some reference point on the base, generally the bottom contact, of an incandescent lamp to the center of the filament. This measurement is of considerable importance, for it greatly influences the design of such accessories to the lamp as reflectors, glassware, lamphouses, etc. *Light center length* is of special importance with focus type or concentrated filament lamps used in optical systems.

Lighting System

The lamps, reflectors, globes, etc., fitters, supports, or fixtures which supply the illumination in a given area. Information on the spacing of outlets and height of lamps above the floor or ground would also be included in a complete description of a lighting system.

Lighting Unit

In general, a lamp with the necessary supporting and light redirecting accessories, as reflectors, glassware, etc. (*See Luminaire.*)

Light Source

Any object or surface which emits light, either naturally or artificially, directly or through reflection.

Line of Vision

An imaginary line extending through the eye in a direction in which a person is likely to look. The most common direction of sight is straight ahead at a slight angle below the horizontal,

but lines of normal vision may extend as high as 14 degrees or more above the horizontal. 14 degrees, however, has been taken by common consent as an upper limit. Good practice has therefore generally dictated the design and location of lighting units so that brilliant light sources cannot be seen without looking upward at an angle of more than 14 degrees. (*For illustration see Glare.*)

Localized Overhead Lighting

A modification of general overhead lighting employing an arrangement of light sources placed with respect to machines, benches, or desks, to provide increased illumination or a preferred direction of light for the more important points in the room or area.

Local Light

A lighting unit, consisting ordinarily of a low wattage lamp in a small reflector, which is placed close to the work for illuminating a small area to a high intensity. Lighting at the needle point of stitching machines in clothing and shoe factories is an example of where such units are employed.

The unit is generally movable so that it can be placed in any position desirable for the work at hand. The strongly local character of the illumination provided, the likelihood of glaring reflections from the polished machine parts, and the possibility of the unit providing a flickering illumination due to machine vibration, make it a generally undesirable form of lighting which should not be used unless absolutely necessary.

Local Lighting is a system by which a single luminaire or lamp is depended upon to illuminate small areas, such as benches, desks, or machines. The lamps are usually placed close to the work, so that little, if any, general illumination of the room or area results. Local lighting is, therefore, rarely suitable, except as a supplement to general overhead lighting.

Louver

A shield which is placed in the path of light to eliminate a part which is not desired. Unless very precise sources and reflecting devices are used to control light, it is not generally possible to confine light to definite paths. Wherever it is necessary to do so, fairly accurate control over the field of the lighted area can be obtained by using *louvers* placed in the form of a grid over the mouth of the lighting unit to cut off the stray light which ordinarily would extend beyond the field to be lighted.

Such *spill shields*, or *louvers*, can be placed parallel to each other and edgewise to the mouth of the lighting unit, or can be formed into a nest of circular shields, depending upon the service for which they are intended.

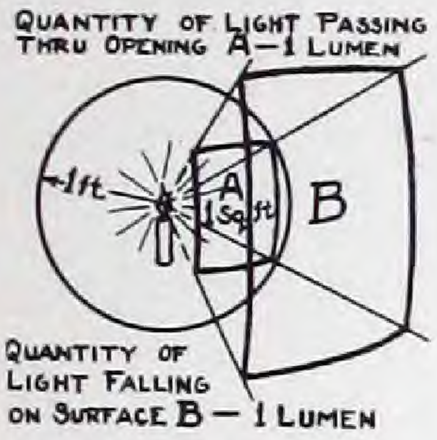
Lumen

The unit of luminous flux: the amount of light (1) emitted over a given solid angle around a source or (2) received on a given area. It differs from the candle or foot-candle in that it takes account of the extent of space or area over which the light is distributed. It is obvious that for a given illumination the flux or amount of light (lumens) varies directly with the area over which this illumination is distributed. Whether representing light sent out by a source or received by a surface, a lumen represents the same amount of light.

With reference to a source one lumen is the amount of light emitted by a uniform source of one candlepower over a steradian, or unit solid angle. If we assume the light source to be at the center of an imaginary sphere of one foot radius, a steradian will cover an area of one square foot on the surface of this sphere. Since such a sphere has 12.57 (4π) square feet of surface, the total light given by a source of one mean spherical candlepower is 12.57 lumens.

The formula for calcu'ating the lumens in any zone or solid angle, is, therefore:

Lumens = Mean Candles x Steradians.



Specifically,

Total Lumens = Mean Spherical Candles x 12.57.

With reference to light received on a given surface, one lumen equals one foot-candle distributed over one square foot.

Lumens = Average foot-candles x sq. feet of area.

Conversely,

Foot-candles = Lumens per square foot.

In the above we have defined the lumen as a quantity. Strictly speaking, it is a rate of light flow, but for practical purposes it is simpler and more convenient to consider it as a quantity. This corresponds to the watt in electrical measurement, which, while strictly a rate of energy flow, is often conceived of as a quantity. True quantity of light would involve the element of time, as for example, in the *lumen hour*, which is the product of the lumens and the time over which they are emitted or received.

Lumens per Watt

The expression generally used to denote the efficiency of incandescent lamps. It represents the quantity of light (in a practical sense) obtained from an incandescent lamp (or other source) per unit of electrical power supplied to the source.

It is a logical and convenient method of expressing the efficiency of light sources, since a higher figure denotes a greater efficiency. The old method, using a watts-per-candle basis, gave a decreasing figure to express an increasing efficiency, which was a difficult thing for the layman to grasp.

The efficiency of a lamp in the beginning of its life is expressed in *initial lumens per watt*. The average efficiency of a lamp throughout life is expressed in *mean lumens per watt*. As a basis for life tests lamps are operated at an efficiency known as *standard comparison lumens per watt*.

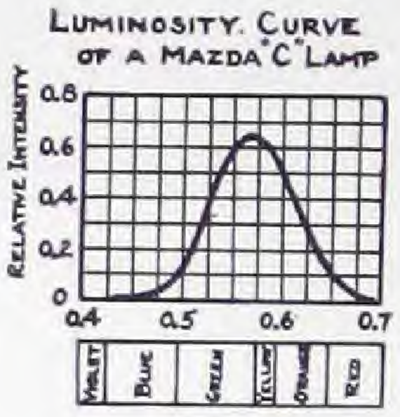
Luminaire

The French word meaning a lighting fixture or complete unit; officially adopted by the Illuminating Engineering Society to denote the combination of light source with its direct appurtenances such as globe, reflector, refractor, housing, and support.

Luminescence

An emission of light caused by a change in the nature of the luminous material, as distinguished from light produced directly by a high temperature. Luminescence occurs at low temperature, though not necessarily so. *Fluorescence* and *Phosphorescence* are forms of Luminescence.

Luminescence can be induced by friction, by chemical action, by excitation of gases in a vacuum when subjected to electric oscillations of high frequency, by suddenly warming certain bodies previously exposed to light, by exposing certain bodies to light, and by a number of other methods.



Luminosity Curve

A curve showing for each wavelength from a light source the luminous flux (light) per element of wavelength. It gives, therefore, wavelength by wavelength, the product of the radiant flux (visible and invisible) and the visibility.

Luminous Bowl

A type of indirect lighting unit in which provision is made for rendering the bottom of the fixture luminous. When such a unit is used the luminaires do not appear as dark spots against the illuminated ceiling, which may be the case when opaque indirect fixtures are employed.

Luminous Efficiency

The ratio of the luminous flux (light) to the total radiant flux (infra red, visible, and ultra-violet rays) from a source. For practical purposes it is usually expressed in lumens per watt of radiation. This should not be confused with term efficiency as applied to a practical light source. (*See Efficiency of a Source.*)

Luminous Intensity

(*See Candle.*)

Lux

The practical unit of illumination, using the metric system of measurement, the illumination of a surface one square meter in area receiving an evenly distributed flux of one lumen, or the illumination produced at the surface of a sphere having a radius of one meter by a uniform point source of one international candle situated at its center. Since 1 sq. meter is equal to 10.76 sq. ft., one foot-candle is equal to 10.76 lux. This unit is used in France and other countries where building dimensions are given in meters.

Maintenance

The periodic cleaning of lighting equipment and the replacing of burned out or blackened lamps.

A lighting installation, like any piece of mechanical equipment, will depreciate with time if no efforts are made to keep it up to full working efficiency. Dust will accumulate on lamps and reflectors, lamps will fall off in candlepower, and so on. Unless steps are taken to *maintain* the installation, the illumination provided by the system will gradually decrease. In every well managed plant a carefully supervised maintenance system should be in force.

Mangin Mirror or Reflector

A reflector (producing approximately the same effect as a parabolic reflector) which consists of a glass mirror, so designed as to have no spherical aberration, with two spherical but not concentric surfaces. Light from a point source at the focus of this reflector is redirected by reflection and refraction in a parallel beam. This device is named after its inventor, Mangin, a Frenchman.

Marker Lamp

A signal lantern carried on the rear end of a railroad train.

Mat or Matte Surface

Any surface which scatters completely light falling on it so that the surface appears of almost equal brightness, no matter from what direction it is viewed. (*For illustration see Diffuse Reflection.*)

MAZDA Lamp

The trade mark MAZDA is not the name of a thing but the name of a service. This trade mark, registered in the United States Patent Office, on an incandescent lamp signifies that the Manufacturer of the lamp has had the advantage of the most recent findings of the Research Laboratories of the General Electric Company.

A MAZDA lamp is always the product of the latest and best methods of incandescent lamp making.

The filaments of all MAZDA lamps are at present made of tungsten. When any material more suitable for the purpose is discovered or developed, it will be used.

In a MAZDA B lamp the filament operates in a vacuum.

In a MAZDA C lamp the filament operates in an inert gas.

Mean Hemispherical Candlepower

The average candlepower of the lamp in the hemisphere under consideration, either the upper or the lower. It is equal to the luminous flux (light) emitted in that hemisphere divided by 2 x 3.14 (6.28).

Mean Horizontal Candlepower

The average candlepower in the horizontal plane passing through the luminous center of a lamp.

It is here assumed that the incandescent lamp (or other light source) is mounted in the usual manner, with its axis of symmetry vertical.

Mechanical Equivalent of Light

If a hundred per cent conversion of energy to light of the wavelength of maximum visibility were possible, the amount of energy required for the generation of one lumen would be 0.0015 watts. The color of this light would be yellow-green (wavelength 0.556 microns).

This is called the mechanical equivalent of light, and the reciprocal of this figure represents the maximum light possible from one watt (668 lumens).

Micron

A unit of length equal to the thousandth part of a millimeter or the millionth part of a meter. It is used in measuring wavelengths of light, degree of vacuum (height of a column of mercury as in a barometer but measured in microns or fraction of a micron), and in other cases where very short distances are concerned. The so-called visible spectrum includes wavelengths from approximately 0.4 to 0.7 microns. It is indicated by the symbol μ (mu).

Millilambert

(See Lambert.)

Miniature Lamp

Although the miniature lamp class designates broadly those lamps fitted with other than medium and mogul bases, the final determination as to whether a lamp is listed as a large or miniature lamp depends upon the service rather than the construction, for example, railway signal lamps, and lamps for decorative service, are classified as large lamps, even though fitted with bayonet candelabra or candelabra screw bases.

Mirror

The surface of every object is, comparatively speaking, rough, some much rougher than others. The surface of even a polished object, if viewed under a powerful magnifier, will be revealed as a series of humps and depressions, very small, it is true, but nevertheless, visible.

If the irregularities in the object are large enough, light striking it will be scattered in all directions as from the surface of a piece of blotting paper.

If the irregularities are very minute so that the distance from one projection to the next is less than the wavelength of light, such a surface will have the property of forming an image of any object placed before it. Therefore, a highly polished surface meets the condition set forth and is said to be a mirror.

Mirrored Reflector

It is common practice when making mirrors for light projection purposes to use a glass form (of the desired shape) and place on its rear surface a layer of silver. This thin reflector of silver is supported and protected in front by the glass, and in the rear, by a coating of copper or heavy paint. Such reflectors are quite durable and their reflecting surface does not rapidly depreciate. Polished, or nickel-plated metal forms are also in common use.

Modified Light

Light which has been passed through either a diffusing or colored medium so that either its general direction or color composition is changed. More generally applied to color modification.

Monochromatic Light

Light of a single spectral hue having a narrow range in wavelength, such as red, green, or blue.

Moonlight Intensity

An intensity of about 0.025 foot-candles used frequently as a general basis of comparison in street lighting.

Mounting

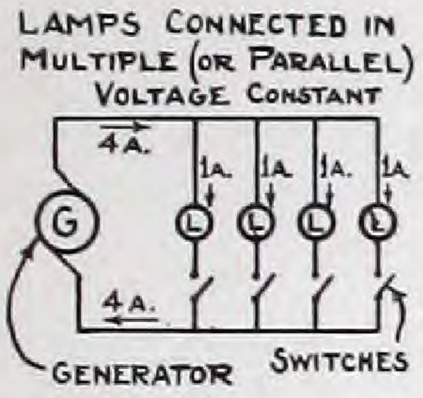
The means of suspending or supporting lighting units.

Multi-directional Lighting

The use of a number of light sources to illuminate an object from all sides. The shadows which result are much fainter

than the dense shadow with sharply defined edges that is cast when the same object is lighted by a single light source of relatively small area.

Multi-directional illumination forms the basis of so-called *general* lighting.



Multiple Circuit

An electrical circuit having a number of paths in parallel arrangement. It is the practice to operate a multiple circuit at constant voltage. The total current in the circuit is the sum of the currents in the different paths. It is possible to extinguish any one lamp without affecting the others. Multiple circuits are used exclusively in all fields except street lighting, where the series circuit predominates.

Multiple Lamp

Lamps designed to operate in multiple or in parallel on constant voltage circuits, as distinguished from series lamps which are designed to operate on constant current circuits.

Multiple Reflections

This is best illustrated by the following phenomenon: If a lamp or other object is placed between two mirrors nearly parallel to and facing each other, a series of images of the lamp will be seen in each mirror, the appearance being that of a string of lamps (in each mirror) starting from an infinite point and increasing in size as the observer is approached.

This is due to the reflection and counter reflection of the same image in each mirror from one to the other.

The same thing can be observed, to a lesser degree, when a bright object is imaged by a thick piece of plane glass since the two surfaces of the glass act as parallel plane mirrors, as described above.

Nadir

In lighting terminology, the direction on a photometric distribution curve directly beneath the center of the lighting unit, and through which the vertical axis of symmetry of the lamp passes.

It marks the zero position on the curve from which all angles are measured.

Natural Colored Lamps

A lamp having a bulb of transparent colored glass as distinguished from a dipped or sprayed colored lamp.

Navigation Lights

Port, starboard, and tail lights on airplanes and ships.

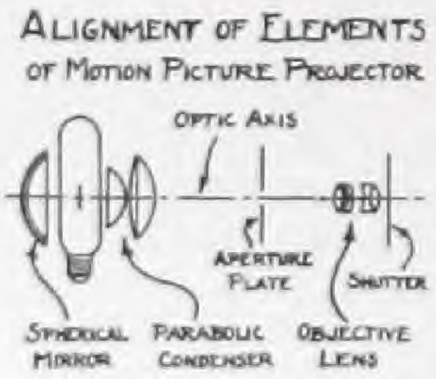
North Sky Light

Light equivalent to that which would be received in a room with but a single window, and that exposed to the north. No direct light from the sun would enter the room, but only such light as had been diffusedly reflected from the sky.

The light received from the north sky is of a particular spectral composition different from that received directly from the sun, since it contains more blue than the latter. It is much used in industry for the matching of colors, as it is of fairly constant value, which permits its use as a standard.

Number Light

In railway practice, a small lamp placed behind a transparency inside of the headlight casing on a locomotive showing its number.



Objective Lens

The lens or system of lenses in an optical device which functions to form the image of the object. In the stereopticon or motion picture projector the objective lens is used for the purpose of forming the image of the slide upon the screen.

Obstruction Light

A red fixed light placed on all objects around aviation fields which are considered obstructions to landing or taking off.

Opaque

Impervious to light rays. The quality of an object or material that prevents the transmission of light. This quality as regards materials is relative; for example, gold is ordinarily regarded as opaque, but in very thin sheets becomes translucent. Conversely, certain materials ordinarily regarded as transparent or translucent, if sufficiently thick, become opaque. It is therefore common in speaking of materials to refer to the degree of opacity somewhat as a reciprocal of transmission.

Optic Axis

(*See Axis.*)

Optic System

A train of lenses, mirrors, prisms, and other optic elements arranged to perform a certain function. Common usage includes also the light source (if one is used).

Out of Focus

When a picture projector or other image-forming system is so adjusted that no sharply defined image is obtained. (*See In Focus.*)

Output

The light given off by a lighting unit of any kind, after the losses due to reflection and transmission are deducted. It represents the light useful for illuminating purposes before further loss due to absorption by walls, ceilings, etc., is experienced.

Over-all Length

The distance from the end of the bulb of an incandescent lamp to the end contact oft he base. (*For illustration see Light Center Length.*)

Over Lighting

An imaginary condition which is said to exist when a lighting installation is claimed to produce too much illumination.

The fact that the eye can easily accommodate itself to thousands of foot-candles of daylight intensity is fairly conclusive proof that there is little danger to be feared from 10, 20, or 30 foot-candles of artificial illumination.

Over lighting, when investigated, has been found invariably to be *glaring lighting* of an intensity *lower* than that which should have been provided.

Over Voltage and Under Voltage

A voltage impressed across a lamp which in the case of over voltage is greater, or in the case of under voltage less, than that specified for its proper operation. If a lamp is operated at over voltage the light generated will be greater; if at under voltage, less.

If a lamp is operated at over voltage its life will be shortened; conversely, if it is operated at under voltage the efficiency and light output will suffer.

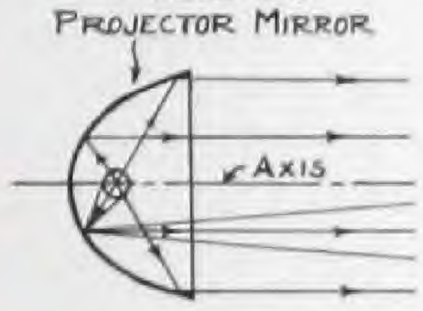
This balancing of life against light is used as the basis for determining economical operating point of the lamp.

Parabolic Reflector

A reflector or mirror which has its reflecting surface in the form of a paraboloid; that is, every cross section containing the axis as an element is in the form of a parabola.

Concentrated beams of light, having small angular diversion, are much used for the illumination of objects or areas from remote points. To obtain the necessary beam of small diversions, mirrors of special shape are used to intercept a large angle of flux from the source and confine it to the small beam for projection at great distance. The parabolic reflector is commonly used for this purpose.

PARABOLIC PROJECTOR MIRROR



Such a reflector possesses the property that when a source of light is placed at its focal point, each point on the reflector receiving light from the source (in the form of a rough cone) will reflect this light in direction parallel to the principal axis of the mirror. Since a cone, instead of a single ray, is received by each reflector point, true parallelism of the rays composing the beam will not result but, rather, the beam will be made up of a large number of small beams (from each point) the angular diversions of which will depend upon the size of the source and its distance from the point in question.

The divergence of the final beam, however, will be measured by the angle subtended by the source (when at the focal point) at the center of the mirror so that the focal length of the mirror and the size of the source are the only factors which govern the spread of the beam in such a projector. The spread, however, is increased by moving the light source away from the focal point of the mirror.

The brightness of the source and the diameter of the mirror control the beam candlepower along the axis of the beam, the variation being directly as the source brightness, and the square of the diameter of the mirror.

Persistence of Vision

Illustrated by the following phenomenon: After the eye has observed an object for an appreciable time, the removal of the object, or the shifting of the eye to another point of observation, will not cause the immediate cessation of sensorial transmission to the brain. In other words, after the object has vanished the brain will still receive the impression for a brief time that the object is before the eye. This is known as persistence of vision.

This effect is most pronounced with a brightly lighted object in a field of low intensity. A familiar illustration of this

tendency of the eye to retain an image is the manner in which the separate screen images in motion picture projection are transmitted as a continuous sequence of events to the brain.

Phosphorescence

The general property of emitting light without sensible heat. Specifically any substance which, after exposure to light, possesses the property of shining in the dark is said to be phosphorescent. This is one form of luminescence.

Phot

A unit of illumination in the metric system, one lumen per square centimeter.

1 phot = 1000 milliphots = 10,000 lux = 929 foot-candles.

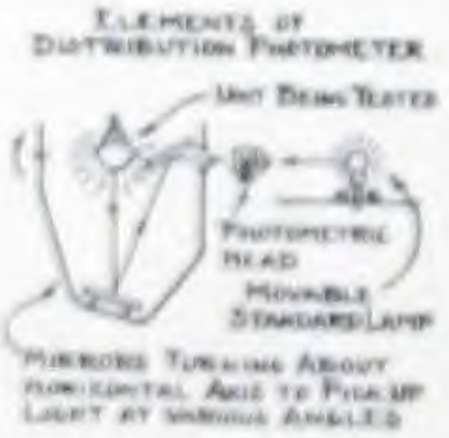
Photographic Blue

The term applied to incandescent lamp bulbs of a special blue glass for filtering out light of long wavelengths. The remaining flux has a proportionately higher actinic, or photographic, value than the longer red rays.

Nothing is added to the light by the glass itself to render it more actinic in value, since a subtractive process only is involved. The principal reason for this filtering process is due to the fact that to secure quick photographic action under even ordinary conditions so much non-useful light would be present as to give rise to undue glare. Photographic blue bulb lamps however, as actually manufactured, operate the filament at a higher temperature than normally so that the actinic light output is materially increased.

Photometer

An instrument used for measuring light intensities. Briefly, it is an incandescent lamp, the candlepower of which is known and calibrated with respect to a scale of foot-candle values marked on the photometer. The light from this lamp is then balanced on a photometric screen with that received from the lamp under test.



The human eye has the power of recognizing equality of brightness on adjacent fields, the degree of accuracy depending upon the similarity of colors. In obtaining the balance, the illumination received from one or both of the light sources is varied by changing the relative distances or by other means until equality of brightness is obtained. The candlepower of the unknown source can then be calculated or read directly from a scale provided for the purpose.

Photometers take a variety of forms, the distinguishing feature being a balance of accuracy against portability. The least portable are, obviously, the most accurate and vice versa. Lamps used for such purposes are known as *photometric standards*.

Pick-up Distance

For any projector, the maximum distance at which a given object may be recognized.

The term pick-up distance is frequently used in connection with railroad headlights, e.g.: The federal law requires that all steam locomotives have a headlight of such intensity that it can *pick up* a man in dark clothing at a distance of 800 feet.

Point by Point Method

The old method of making illumination calculations involving the computation, for each point of the illumination received from every source effective in supplying that particular point with light, using the cosine law of illumination, q. v.

This method, needless to say, is very tedious and has given way to a quicker method based on the flux effective after allowance has been made for the various losses due to absorption in reflectors, walls, ceiling, etc. (*See Flux of Light Method.*)

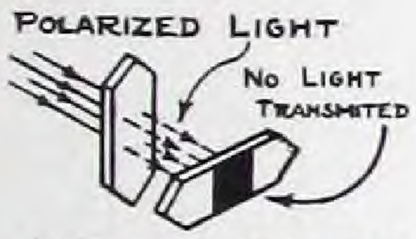
Point Source

A light source having no dimensions. Classical optics, as expounded in college textbooks, make use of a point source, usually on the optic axis, in explaining the action of lenses, mirrors, etc. Such a source exists in theory only, since the practical condition involves a source having appreciable area, which fact greatly affects the optical results obtained with any device.

It is true that the use of a point source is of value when exploring the action of lenses and mirrors, and that of any source occupying different positions.

The fact to be kept in mind, however, is that a large number of points (instead of but one) are effective in supplying the lens with light, and the combined effects of all these points must be considered simultaneously.

Polarization



A POLARIZING CRYSTAL TRANSMITS LIGHT WAVES HAVING ONLY ONE DIRECTION OF VIBRATION

A peculiar directional characteristic of light rays produced either by reflection or by transmission through a Nicol prism (Iceland spar). The undulatory theory conceives of an ordinary light ray as a vibration in all directions perpendicular to the ray. In a ray of polarized light the vibration seems to be limited to a single direction which affects the action of the light under certain conditions. The fact that moonlight is partially polarized is said to give it certain valuable properties in connection with plant growth. (*For fuller description see a textbook on physics.*)

Porcelain-enamel Finish

A white porcelain layer applied to industrial type steel reflectors, which acts as a reflecting surface and protective coat. (*See RLM Standard Dome.*)

Power Consumption

The electrical energy required to operate an electrical device. The power so used, multiplied by the time, in hours, of use, determines the total energy consumed, and forms the basis of the charges made by Electric Service Companies in selling electricity.

Primary Colors

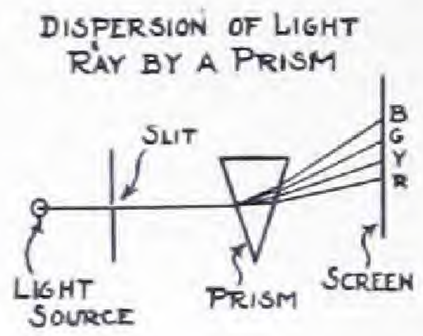
In light, red, green, and blue. These three colors, when mixed in the proper proportions, will give white light and by the same means any color of the spectrum may be duplicated. Color values in light are obtained by the additive process which accounts for the difference between the primary colors of light and those of pigments; the primary colors of the latter being red, yellow, and blue.

Color values in pigments are obtained by the subtractive process (acting through the agency of absorption in the pigments.)

Primary Standard

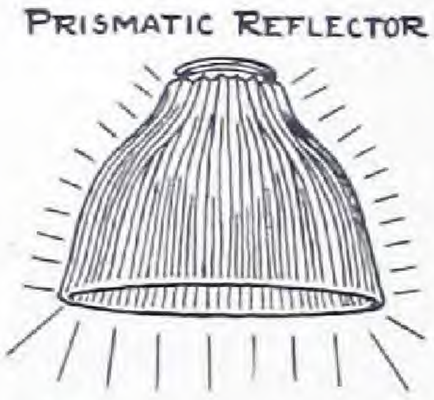
A standard by which the unit of light is established, and from which the values of other standards are derived. A satisfactory primary standard must be reproducible from specifications. There is no generally accepted primary standard of light, although a very promising one has been proposed and is being considered for adoption by the International Commission on Illumination. Our present standards were originally based on the candle, but as candles were subject to so great a variation, it has been found necessary to preserve the standard in the form of incandescent lamps. Such standard lamps are maintained by the Bureau of Standards in Washington and the national laboratories of Great Britain and France.

Prism



A wedge-shaped piece of glass which possesses the property of refracting a beam of light and dividing it into its component colors, arranged in order of wavelengths. The banding of colors resulting is referred to as the *Prismatic Spectrum*. See also *Diffraction Spectrum*.

Right angled prisms are also used for reflecting a beam of light at right angles to the original direction of the beam. Such elements are used in prism binoculars for obtaining long focal length in a small, compact unit, since the light beam is caused to double back on its path twice before entering the eye.



Prismatic Reflector

A reflector of glass having its surface fluted with prismatic wedges to reflect totally the light received from the source, causing it to return and issue from the mouth of the reflector in a certain predetermined manner, depending upon the distribution of light desired.

Productive Lighting

Illumination of a higher order than that ordinarily used for industrial processes. It derives its name from the fact that, over a certain range, any appreciable increase in illumination is accompanied by a stimulation of visual sensation which permits greater and more rapid perception of detail. The net result, as far as work is concerned, is an increase in output.

There may be an upper limit, of course, beyond which it would be uneconomical to raise the illumination, but experience seems to indicate that the limit is far above the levels found in present day installations.

Projection Distance

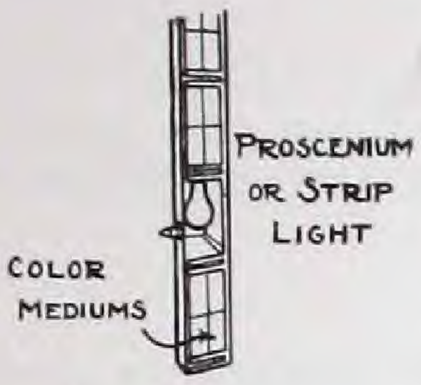
The distance from the source to the place where the projected light is to be used. Sometimes called "*throw*."

Projection Lens

(*See Objective Lens.*)

Projector

A device for projecting light. Since the term is used in a number of different senses, the type of projector referred to should always be mentioned, as motion picture projector, floodlighting projector, etc.



Proscenium Light

A row of lamps with suitable reflectors located at the sides of a stage opening or proscenium.

Purkinje Effect

The greater sensitiveness of the eye under low intensities to light rays of short wavelengths, as blue and green, as compared to rays of longer wavelengths, as yellow or red.

Quality of Lamps

There are three main factors which indicate the inherent quality of lamps—efficiency, life, and lumen maintenance, q.v.

Quality of Light

In ordinary usage, the color composition of light. (*See Modified Light.*)

Quantity of Light

(*See Lumen.*)

Radiation

The act or process of transfer of energy, such as light, heat, X-rays, etc., through space. The term also refers to the energy so transmitted. *Radiant Flux* or the *Rate of Radiation* may be expressed in ergs per second or in watts. Light is one form of radiation and is commonly referred to as *Visible Radiation*.

Rating

A statement of the principal operating values for which a particular lamp is designed.

In American practice, multiple lamps are rated as to volts, watts, and lumens per watt, and series lamps are rated as to amperes, lumens, and lumens per watt.

Ray

The straight-line path traversed by an infinitesimal amount of radiant flux when passing from one point to another, or from the source to another body. Emissions from radiant bodies pass off in straight lines upon leaving the source, and continue in straight lines when passing through any homogeneous substance.

A *Light Ray* is one of the lines of light which appear to radiate from a bright object. The term is also used to refer to the light of a specified wavelength.

Redirection

The altering of the direction of light from a light source. Light upon leaving the source will pursue a straight-line path unless means are taken to change its direction. Since the light from incandescent lamps is given off in all possible directions, and since, furthermore, certain planes are usually favored in illumination practice, it is necessary to effect a redirection of much of the light flux after it leaves the source.

This is accomplished by interposing reflectors, lenses, diffusing glass, prisms, and other optic devices in the path of the flux so as to redirect it to the desired plane.

Such redirection forms the basis of scientific design of lamp accessories.

Reduction Factor

In a lamp, the ratio between the mean spherical candlepower to the mean horizontal candlepower. The term is going out of use since lamps are no longer rated in horizontal candlepower.

Reflected Image

In general lighting practice, this term denotes the glaring reflection of light sources from polished surfaces encountered in industry and commerce. Particular caution should be exercised to guard against such reflections in work places.

Images, as formed by mirrors, fall within two distinct groups, *real images*, such as those which are formed by concave mirrors, and which can be projected onto a screen, and *virtual images*, such as those which are formed by plane and convex mirrors, and which cannot be projected onto a screen.

In the strict sense of the word, only real images are reflected, since virtual images are in the nature of an optical illusion, there being possible no crossing of the rays—a condition which is necessary to real image formation.

Reflection

The light flux striking an object which is turned back (i.e., is neither transmitted nor absorbed).

Light striking any object will either be absorbed, transmitted or reflected. No object will perform any one of these operations perfectly, the practical condition being that most objects both absorb and reflect the light incident upon them, while many objects perform all three operations, in that they partially reflect, absorb, and transmit the incident light.

The percentage of incident light reflected by an object is called its *reflection factor* and is used as a criterion of the reflectivity of that particular object.

The degree to which an object receiving light upon its surface can reflect it is called its *reflectivity*.

Reflector

Any object which to a marked degree possesses the property of reflecting light; specifically a device for redirecting light by reflection. Reflectors may be rough in surface (as a block of magnesium carbonate, or an aluminum-painted surface), or they may be more or less highly polished (as a mirror) in order to control the direction of the reflected light.

Refraction

The bending of a light ray that occurs when leaving one medium of certain density to enter another of greater or lesser density.

The ray after the bending occurs is called the *Refracted Ray*. (*See Index of Refraction.*)

Refractor

A device (generally of glass) especially designed to take advantage of the phenomenon of refraction to control the direction of the emergent rays.

This principle is used in street lighting equipment, auto headlamp lens, prism window glass, etc.

There are three general types of refractors used in street lighting: a *Band refractor*—open at the top and bottom—the larger opening at the top, with straight sides; a *Bowl refractor* open at the top, closed at the bottom, a combination

of straight and curved sides; a *Dome refractor* open at the bottom, a narrower opening at the top, curved sides. All three types may be furnished for either symmetrical or asymmetrical distribution.

Regular Lamps

Those incandescent lamps which are in considerable demand and ordinarily carried in stock, as distinguished from those for which there is a limited demand and which are made up on order.

Regular Reflection

Reflection in which a ray of light striking a surface at an angle will be reflected in such a direction that a perpendicular to the surface at the point of reflection will bisect the angle formed by the incident and reflected rays, or in other words, so that the angle of incidence will be equal to the angle of reflection. Light striking a mirror, for example, is reflected in accordance with this characteristic. (*For illustration see Angle of Reflection.*)

Ribbon Filament

As distinguished from the commonly used wire filament (of incandescent lamps), a filament consisting of a flat ribbon of tungsten, either plane—to present a smooth surface to certain optical devices—or crimped, saw-tooth fashion, to obtain the benefit of multiple reflections between the surfaces of the crimped sections in raising the brightness of the filament for any given power consumption.

R. L. M. Standard Dome Reflector (*Reflector and Lamp Manufacturers' Standard*)

A dome shape porcelain enameled steel reflector, the reflecting surfaces of which are coated with white opal glass. The relatively large diameter assists diffusion and softens shadows; and this is probably the most popular reflector for industrial lighting.

The output is approximately 75 per cent of the light produced by the bare lamp. The light is delivered below the horizontal with a cut-off at 72½ degrees. The light between 72½ degrees and the horizontal is least useful and most likely to produce glare, hence, the desirability of cutting it off and reflecting it down.

R. L. M. Reflectors are for use with the clear, inside frosted, or white bowl MAZDA C lamps, the last assuring a better degree of diffusion.

Reflectors are designed by lamp wattage, as follows:

R.L.M. 60 (Also for 50-watt lamp)
R.L.M. 100
R.L.M. 150
R.L.M. 200
R.L.M. 500 (Also for 300-watt lamps)
R.L.M. 1000 (Also for 750-watt lamps)

R.L.M. domes are made by the leading reflector manufacturers under quality specifications prepared by the reflector and lamp manufacturers. The conformation to the specifications is assured by periodic inspections and tests by the Electrical Testing Laboratories, which issue certificate labels.

The trade name is the property of the General Electric Co., who have contracted with the Electrical Testing Laboratories for the administration of the system in the interest of better lighting practice.

Room Index

A constant used in lighting calculations which takes into account the proportions of the room in conjunction with the hanging height of the lamps. It is a necessary element of lighting calculation, since more light would be lost on side walls, for example, in a high narrow room than in a low wide room.

Runway Marker

A green fixed light at edge of airport fields to indicate favorable approach to runway.

Saturation

The degree of freedom of a color from admixture with white. Monochromatic spectral light may, for purposes of measurement, be considered as having a saturation of 100 per cent. As white light is added, the saturation decreases, until, when the hue entirely disappears, the saturation is zero. White, therefore, is the limiting color having no hue, and zero saturation.

Screen

Any object interposed in the path of a light beam for

(a) Eliminating stray light.
(b) Reducing the intensity of light in the beam.
(c) Removing certain colors from the light.
(d) Rendering the projected image of a picture visible to a group of people, as a motion picture screen.

The function of a motion picture screen is to reflect light, as efficiently as possible, from each point of screen surface over an angle depending upon the proportions of the viewing area.

Searchlight

INCANDESCENT SEARCHLIGHT

A device consisting of a long focal length parabolic (or Mangin) mirror of the required diameter with a small light source of high brightness placed at the focal point.

The principal function of such a unit is to illuminate a small area located far away from the light source. The maximum distance at which objects within the beam can be recognized is called the "pick-up" distance or range of the searchlight. (*See Floodlight and Parabolic Reflector.*)

Secondary Standard

A standard calibrated by comparison with a primary standard. The use of the term may also be extended to include standards which have not been directly measured against the primary standards, but derive their assigned values indirectly from the primary standards.

Selective Absorption

The property of materials whereby certain wavelengths or colors of light are absorbed in greater proportion than other colors. A red object has selective absorptions for colors complementary to red, thus reflecting or transmitting a larger proportion of red light. White, black and gray materials have no selective absorption but absorb all colors in equal proportion, black having maximum and white minimum absorption. (*See Color Filter.*)

Selective Radiation

Used in two senses. As applied to *luminous gases*, the property of radiating light of certain wavelengths or colors peculiar to the gas and practically independent of the temperature. The spectrum of a gas is made up of bright lines corresponding to the particular wavelengths emitted, all other wavelengths being absent from the light.

As applied to *luminous solids or liquids*, the property of emitting colors in proportions differing from those of the theoretical black body at the same temperature. For any body which is radiating light, the proportion of various colored rays, and therefore, the apparent color of the light, varies with the temperature; but there is an accepted combination for each temperature of the *Black Body*. A given material will vary from this combination in a greater or less degree corresponding to its nature, and this variation is referred to as *Radiation*. (*For fuller description, see Kirschoff's Laws of Radiation, in a standard textbook on Physics.*)

Selective Reflection

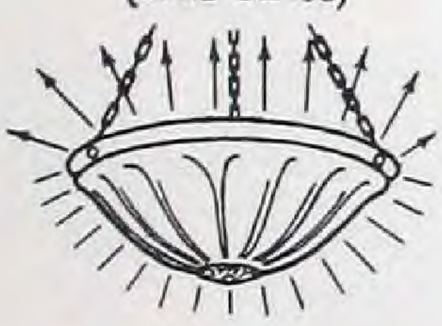
The property of objects which reflect light of only certain colors. (*See Selective Absorption.*)

Selective Transmission

The property possessed by some transparent or translucent materials of transmitting light which is of different color composition from the incident light. A blue glass has a selective transmission for blue, so that compared with the incident light, the transmitted light contains a larger proportion of those wavelengths that produce the sensation of blue. (*See Selective Absorption.*)

Selenium Cell

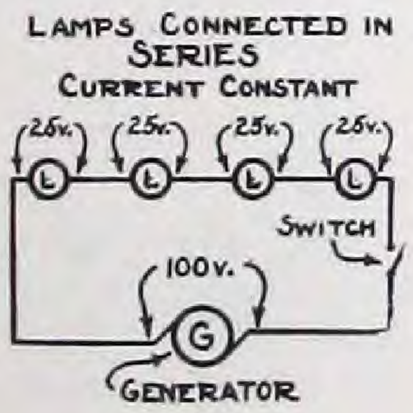
The rare metal selenium has the property of changing its electrical characteristics when light radiation strikes it. This is taken advantage of in constructing a device for automatically registering the intensity of radiation. With proper color selecting screens it can be used to measure light or illumination. Practical use is made of this in the photo-electric cell.



Semi-indirect Unit

A lighting device which directs the major portion of the light flux toward the ceiling or upper side walls from which it is diffusely reflected to the working plane. A part of the light is transmitted through the translucent body of the unit.

Series Circuit



An electric circuit consisting of a single line of conductors arranged so that the entire current of the circuit passes successively through every element. It is the practice to operate a series lighting circuit at a rated current—6.6 amperes being the usual standard in this country. The operating voltage of the circuit varies with the load. To extinguish a single lamp on a series circuit, it is the practice to short-circuit or by-pass it. The opening of a series circuit localizes the full circuit voltage, and is likely to be dangerous. Series circuits are extensively used in street lighting.

Series Lamp

A lamp designed for operation on constant current circuits, or for burning in series with other lamps.

Street series lamps operate either directly on a series circuit or from the secondary of a series transformer or auto-transformer (compensator) fed from such a series circuit. Street series lamps are designed for rated current, usually 6.6 amperes, or, if intended for series transformers, 15 or 20 amperes, depending upon the size.

Street series lamps are rated as to size in lumens. The output is sometimes informally designated in nominal candles corresponding to the former rating in mean horizontal candlepower. This nominal candlepower is one-tenth of the rated lumens. Six hundred candles mean the six thousand lumen lamp. They are not recommended for operation on constant potential circuits as they are liable to give unsatisfactory service. Any improvement resulting in increased efficiency would change the volts and watts for which the lamp is made.

Street series lamps should not be confused with *railway lamps*, which are intended for operation five or six in series on a multiple railway circuit.

Shade

In the early days, a device for shielding the eye from bright lights. The first step in the evolution of the modern reflector was taken when crude metal shades were placed over the lamps for the primary function of protecting the eyes from the bright filament.

It was only natural to provide the inner surface of these shades with a reflecting finish, such as painted enamel, painted aluminum, etc., in order to increase the downward light. By progressive steps the design of the equipment, its construction, and the quality of the reflecting surface were improved until the modern line of lighting equipment, as now available, was evolved.

In modern practice a shade is a shield or covering made of silk, paper, glass, or other material used for decorative effects, and for the reducing of glare from bare lamps but without regard to predetermined redistribution of light.

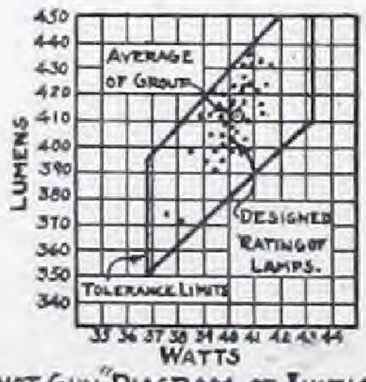
Shade Holder

A device for supporting a reflector or shade from a lamp socket. The holder may be an integral part of the socket, or may be detachable.

There are two principal sizes, designated in diameter, namely, 2¼ in. and 3¼ in. These correspond to similarly designated fitters on reflectors. The 2¼ in. is usually used with the medium screw sockets, and the 3¼ in. with the mogul sockets. (*For illustration see Holder.*)

Shot Gun Diagram

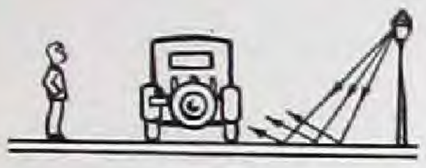
A graphic means of showing the individual characteristics of a group of lamps with reference to two features, for example, watts and lumens. Such a diagram shows at a glance the "spread" from established standards.



"SHOT GUN" DIAGRAM OF INITIAL RATING OF GROUP OF 40W. LAMPS

Silhouette

The effect produced when an object is seen as a dark outline against a brighter background. This condition occurs under dim lighting when the dominant light source is beyond the object viewed. A very large part of our seeing at night by



street lighting is through *Silhouette Vision* where the light from a more or less distant lamp reflected from beyond the object by a glossy pavement makes the background appear brighter than the object itself. While silhouette lighting does not reveal color and detail of an object, it does indicate closely its position, size, motion, and outline, so that the object can usually be identified. It is this phenomenon which makes it possible to get along with low-intensity street and highway lighting.

Silhouetting is also employed for certain theatrical stage effects. (*See also Direct Vision.*)

Side Deck Lighting

A system of railroad car lighting in which the fixtures are placed in two rows, one along each side directly over the seats and below the ventilators.

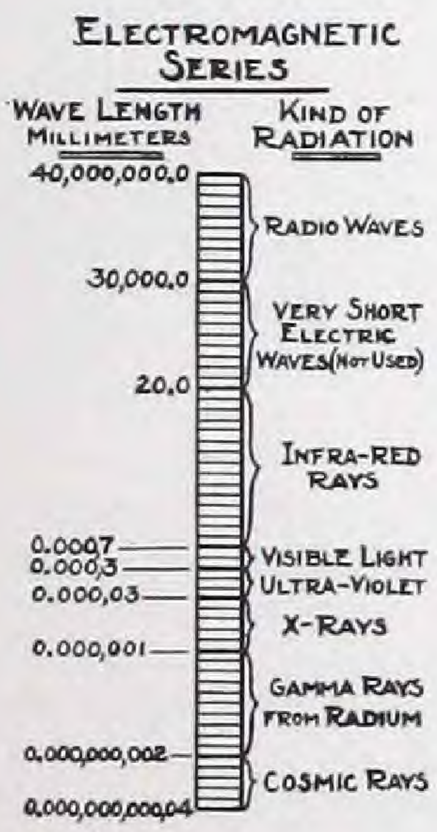
Socket Extension

A device which makes it possible to use a lamp in a reflector which was designed for a lamp of longer light center. If the smaller lamp will not give the distribution of light ordinarily obtainable from the particular equipment, a socket extension, consisting of a female part for accommodating the base of the lamp to be used, and a male part for screwing into the lamp socket, may be used to obtain the normal distribution of light.

Socket extensions are available to adapt the 100-watt inside frosted MAZDA lamp to equipment designed for the longer clear lamp of the same wattage formerly used.

Special Lamp

A lamp of limited application and consequently not listed in the manufacturers standard schedules and not ordinarily carried in stock.



Spectrum

The arrangement of colors in order of wavelength produced when a beam of light is refracted by a *Prism* or *Diffraction Grating*. Of the visible rays, the violets or short wave rays are bent (or refracted) most, and the red or long wave rays are bent least. The order of colors is red, orange, yellow, green, blue, violet.

In the *Prismatic Spectrum*, or that produced by a prism, the red and yellow bands are relatively wider and the blue and violet bands relatively narrower than in the *Diffraction Spectrum* which is produced by a *Diffraction Grating*.

In reality, the spectrum extends in both directions beyond the *Visible Spectrum*, which has been defined above. The invisible radiations beyond the violet end of the *Visible Spectrum* are known as *Ultra-violet* or *Chemical* rays. Those beyond the red end are commonly known as *Infra-red* or *Heat* rays.

Specific Consumption

The consumption per lumen of light output of an electric lamp.

Watts per candle is a term formerly used commercially in connection with lamps and, unless otherwise stated, denoted watts per mean horizontal candlepower.

Specific consumption is an inverse measure of lamp efficiency. (*See Efficiency.*)

Spectrophotometer

A device for measuring the relative amount of energy at different wavelengths in the spectrum of the light source.

Spectrophotometric measurements provide a way of determining the wavelength or color characteristics of light from different sources, also transmitting and reflecting media, such as colored glasses or reflectors.

It is the practice in Spectrophotometry to deal with relative values rather than the absolute values present in any beam of light.

Specular Reflection

(See Regular Reflection.)

Speed of Vision

The action of the human eye is somewhat similar to that of a photographic plate in that the element of time determines the impression made by an image on the retina. At high illumination intensities a given impression will be produced in a shorter interval of time than at lower intensities.

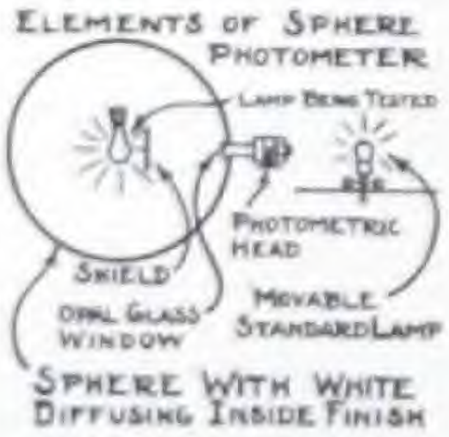
One of the advantages of high levels of illumination is the increased production resulting from the greater ease and safety with which workmen can perform their processes.

Sphere

In photometric measurement, the *Ulbricht Sphere* for the determination of the total output of light sources. It consists of a hollow sphere of certain size (depending upon the work), the inner surface of which is given a coat of special paint selected for its light reflecting properties and its permanence.

The light source to be photometered is placed inside of the sphere. A metal shield cuts off the direct light of the lamp from the photometer head, which is fitted into an opening in the sphere. The light flux, by multiple reflections, is equalized in all directions. A reading in the ordinary photometer method of the flux striking this opening determines the total lumens or spherical candlepower of the source.

Another use of the term *Sphere* is in connection with the concept of an imaginary unit sphere (one foot radius) whose surface entirely surrounds the center at which a light source is located, and therefore intercepts all the light emitted by the source. This is useful in picturing the relations between candlepower, mean spherical candlepower, lumens, and foot-candles.



Spotlight

A device used in connection with a concentrated light source to project a narrow beam of light on an object so as to form a spot of light. Spotlights differ from searchlights in that they are usually of lower power and are employed at short distances, seldom exceeding two hundred feet. *Theatrical and Show Window Spotlights* usually consist of a concentrated filament incandescent lamp and a condensing lens mounted in a light-tight housing. Color screen mountings are sometimes included. *Automobile Spotlights* usually employ short focus parabolic reflectors and are so mounted as to be pointed in desired directions by motorists.

Spotlighting

A form of lighting in which relatively narrow and concentrated beams are directed so as to light brightly objects or clearly defined areas.

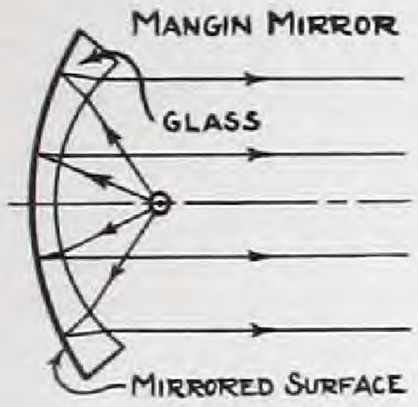
Spread

The angular divergence of a light beam in degrees, measured from the source.

In the case of projectors the spread is governed by the size of the source and its distance from the nearest point on the surface of the lens or reflector with which it is used. (*See Parabolic Mirror.*)

In practical purposes the edge of the beam is often regarded to be at the point where the intensity falls to 10 per cent of the maximum. (*For illustration see Beam Diameter.*)

Spread Beam

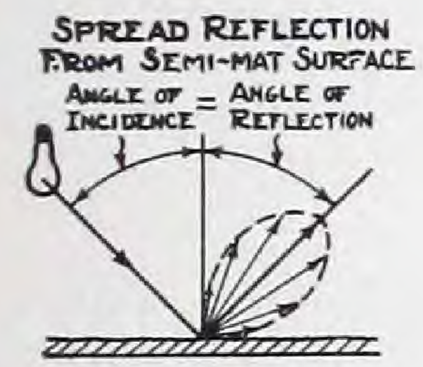


A particular combination of light source (as regards dimension) and a parabolic mirror (as regards focal length) will give a beam of certain diameter which, when the device is properly focused, cannot be made smaller.

The beam can, however, be made larger by the simple expedient of moving the source either closer to, or farther away, from the lens or mirror. This is called "*spreading the beam.*" Whenever it is desired to do this, the source should be moved *closer* to the optic element as a slight increase in light intercepted results, improving the output from the unit.

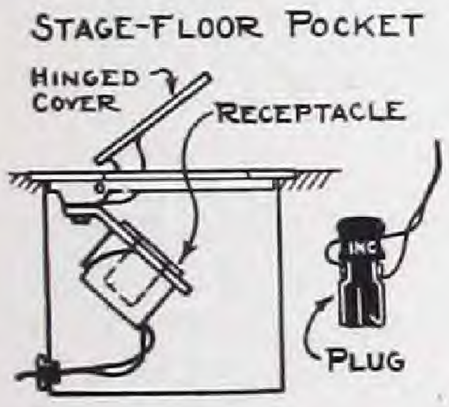
With searchlights, spotlights, and automobile headlights it is common practice to introduce spread in one plane of the beam, say horizontal, by the use of prismatic front glasses.

Spread Reflection



The manner in which light is reflected when it falls on a slightly roughened mirror surface, such as matt aluminum. The reflected light has the same general direction as if the law of regular reflection held, yet the roughened surface introduces a certain amount of diffusion. This has the effect of making the reflected beam of considerably greater spread, and, of course, reduced maximum intensity.

Stage Pocket



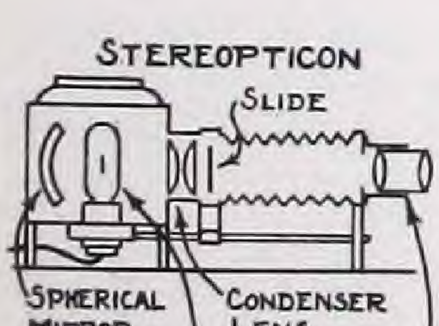
Generally, a recessed plugging box of high capacity to which portable lighting apparatus is attached. It corresponds on the stage to the convenience outlet in the home.

Standard Lamp

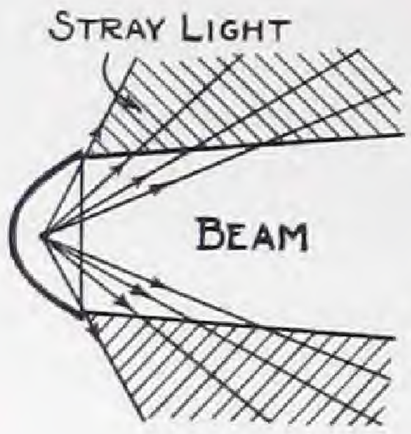
In photometric measurements, a lamp of known lumens or candlepower (spherical or horizontal) at a certain voltage used as a basis of comparison in the photometry of other lamps. (*See Primary Standard.*)

In the trade, lamps which are used in a large quantity are listed in Manufacturer's Price Schedules, and generally carried in stock by agents.

Stereopticon



A device for projecting upon a screen an enlarged image of a partly transparent slide, called a lantern slide; a *magic lantern.* In its common form for use with incandescent lamps it consists of the following elements, listed in order of position from rear to front: Spherical mirror (concentric with the filament), MAZDA stereopticon lamp (concentrated filament), condensing lens, lantern slide holder, and objective lens. These are mounted in a housing and must be accurately positioned and centered along the optic axis.



Stray Light

Light falling outside of a desired beam or wasted.

In any open mouthed projector (floodlight) a certain percentage of the light emitted by the lamp is intercepted by the mirror and directed into the beam. The remainder of the light, or that issuing directly from the lamp without reflection from the mirror is not generally useful unless the unit is used for very short distance work.

The term can be taken to mean any light so wasted by a unit or optic system, which often produces an undesirable lighting effect.

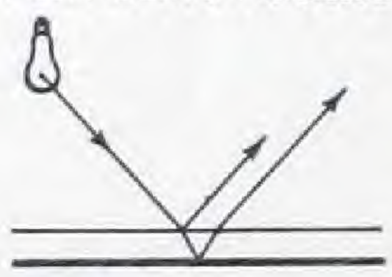
Street Lighting Schedule

A list of hours for lighting and extinguishing street lighting circuits. There are four general schedules in use. The *All Night Schedule*, based on burning the lamps from one-quarter hour after sunset until one-half hour before sunrise, totals approximately 4000 hours a year. The *Midnight Schedule*, based on burning the lamps from one-quarter hour after sunset until midnight totals approximately 2000 hours a year. The *Moonlight Schedule* takes advantage of the moonlight so that on nights when the moon is full or nearly so the lamps are not lighted. On other moonlight nights the lamps are extinguished one hour after moonrise and lighted one hour before moonset. With this schedule the lamps are in operation approximately 2000 hours per year. The *Frund Schedule* takes no account of the moon until after midnight. The lamps are lighted one-quarter hour after sunset and burned until midnight. The lighting hours after midnight are in accordance with the "Moonlight Schedule." With this system the lamps are in operation approximately 3000 hours a year.

Strip Light

On the stage, a row of relatively small lamps, clear or colored, in a narrow trough reflector. This is suspended or placed at some point where a higher intensity of light is needed. (*For illustration see Proscenium Light.*)

Surface Reflection



The reflection of light from the surfaces of glass or other transparent or translucent materials. In a glass mirror the reflection at the front surface of the glass as differentiated from the silvered surface.

If a beam of light strikes normally a piece of clear glass having parallel plane sides, a minimum of 4 per cent of the incident light will be reflected from the surface of the glass, the remainder passing though it, whereupon another 4 per cent will be reflected from the surface. The total reflection loss in such a case will, therefore, be 8 per cent (neglecting multiple reflections which would somewhat reduce this.)

Symmetric Distribution

In a lighting unit, the distribution of light symmetrically in all directions about the vertical axis of the lamp. (*See Asymmetric Distribution. For illustration see Distribution of Light.*)

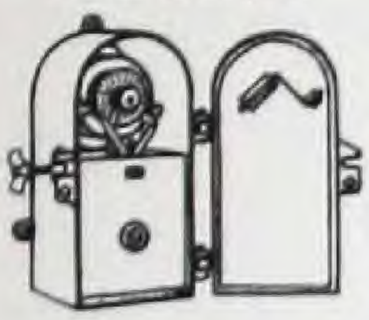
Test Lamp

In photometric measurements the lamp of which the characteristics are to be determined.

Threshold of Vision

The point of minimum brightness at which the human eye begins to perceive. It depends on the brightness to which the eye has previously been exposed and the time that has elapsed since that exposure. After full adaptation to darkness lasting an hour or more, the minimum reached is in the order of 0.0000007 millilambert (0.001 millilambert corresponds roughly to night outdoors), for white light. The threshold value varies with the color of light, also if the object whose visibility is to be tested is of small dimensions it must be much brighter to become just visible, and further, the time of exposure is a factor. It must be borne in mind that the eye perceives with ease and comfort a billion-fold range of intensities.

TIME SWITCH



Time Switch

A clock mechanism which can be set to open and close a switch at any desired time, and so control the burning hours of a sign, show window, or other lighting system.

Tint

The admixture of white with any colored light. The greater the percentage of white, the lighter will the tint become until finally zero saturation of the color will be reached, at which point the resultant light will be white.

The same term is used to indicate the corresponding color characteristics of materials as viewed by white light.

Tolerance

The variance allowed from established standards. Tolerances also apply to the average life and average lumen maintenance of the lamps tested, the tolerance depending upon the number tested. It is impossible to manufacture each incandescent lamp, or any other product for that matter, exactly to a given standard. With the specifications for incandescent lamps are presented tolerance values applying to such factors as initial rating, physical dimensions, etc. These tolerances vary with the type and size of lamp.

Tormentor Lights

On the theater stage, spot lights mounted in a row vertically at the sides just to the rear of the curtain (first entrance) and directed as desired.

TRAFFIC LIGHT

Traffic Light

A lighting unit especially designed for the regulation and guidance of vehicular traffic. It may take any one of a number of forms: an automatic flashing device; a system of three lamps, provided with red, amber, and green glass lenses; a colored light suspended over a road crossing; a rotating light continuously burning which gives the appearance of being flashed.

Translucent

The characteristic of an object which permits light to pass through it and yet, unlike a transparent object, diffuses the light so as to break up images. For example, opal or frosted glass.

Transmission

The passage of light through an object or medium. It may be said that all substances, no matter what their density

may be, will, if made thin enough, transmit light to some degree. The ratio of transmitted light to incident light is known as the *Transmission Factor* of an object, or of a material of specified thickness.

Transparent

The characteristic of an object which transmits light without diffusing it, so that objects can be seen through it without gross distortions.

Ultra-violet Radiation

Invisible radiation of slightly shorter wavelengths than those of the violet light. Its characteristics are evidenced through actinic properties as well as the producing of the effect of so-called sunburn on the skin.

Because of their effect on photographic plates, and in connection with other chemical reactions, ultra-violet rays are sometimes called *Chemical Rays*. Certain of these radiations have power to injure the eye seriously; on the other hand, properly employed therapeutically they have beneficial physiological effects related to the production of vitamines. Quartz is transparent to all but the shortest wavelengths of ultra-violet light. Ordinary glass is practically opaque to such radiation. The absence of ultra-violet radiation is the cause of rickets in human beings and "weak legs" in chickens.

Uni-directional Light

Lighting in which the illumination is projected all in one general direction; for example, railway yard lighting with floodlights, all turned in the direction of car movement; tunnel lighting with reflectors arranged to throw the light in the direction of travel; industrial lighting with angle reflectors, turned so as to simulate daylight from sawtooth skylights.

When facing the direction of lighting no light sources are visible; when facing the light sources the glare is likely to be excessive. Shadows all lie in one general direction and are likely to be more prominent than with symmetrical lighting. When street lamps are placed very far apart, certain sections of the street have uni-directional lighting.

Unit Package

A standardized quantity of miniature lamps. A unit package consists of ten lamps of one voltage, candlepower, base, construction of filament, color, finish, size, and type of bulb.

DISTRIBUTION CURVE OF ENCLOSING UNIT

Upward Flux

All of the light flux emitted by a source above its horizontal plane is referred to as *Upward Flux*.

Utilization Factor

See Coefficient of Utilization.

Vacuum Lamp

An incandescent lamp in which the filament is operated in a vacuum. This type of construction produces best results in low amperage lamps and is employed for 115-volt lamps of less than 50 watts. The term MAZDA B has been used to distinguish vacuum lamps from gas filled, or MAZDA C, lamps.

Vanishing Flicker Frequency

If a beam of light is continuously interrupted in a regular manner, the illumination from that beam, at certain frequencies of interruption, will be evidenced in the form of flicker. The lower the frequency of the interruption, the more pronounced will be the flicker.

As the speed of the cut-offs per second is increased, the flicker will become less pronounced and finally a point will be reached where no flicker whatever will be visible. The frequency at which this occurs is called the *vanishing flicker frequency* and its value is governed by the intensity of illumination, in combination with the color of object on which the illumination falls, and the degree of stillness in the object. The principle finds much application in motion picture projection.

VAPOR-PROOF UNIT

Vaporproof Unit

A lighting unit in which the incandescent lamp is enclosed in an air tight glass housing. Its purpose is to prevent the seepage of acid vapors, water vapor, finely divided grain dust particles (which, when mixed with air become explosive), into the live parts of the socket, or their deposit on the hot bulb, thus setting up a dangerous condition likely to result in corrosion of metal parts, fire, explosions, etc.

Viewing Distance

A term applying to electric signs; the two extremes are:

(a) The greatest distance from which the sign will be seen (used in calculating the proper size of letter).

(b) The shortest distance from which the sign will be seen. (used in calculating the spacing of lamps to give the effect of a continuous line of light).

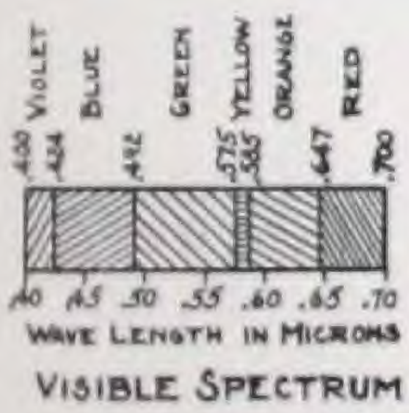
Visibility

The ability to be seen or to facilitate seeing; the distinctness with which objects may be observed. Atmospheric conditions, intensity of light on the object, color of the object, and contrast of object against its field are determining factors in visibility.

Visibility Factor

For radiation at any wavelength, the ratio of the luminous flux at that wavelength to the corresponding radiant flux.

The relative visibility factor for a particular wavelength is the ratio of the visibility factor for that wavelength to the maximum value of the visibility factor.



VISIBLE SPECTRUM

Visible Spectrum

Radiation of certain wavelengths, 0.39 μ (violet) to 0.76 μ (red) that are visible to the human eye. (*See Spectrum.*)

Visual Acuity

Strictly speaking this term applies to the ability of the eye to perceive detail. By custom the term has come to mean the power of the eye in distinguishing objects which subtend an angle of 5° upon the eye. Visual acuity is determined by having the subject observe the card on which lines of printed matter of various sizes are placed (Snellen's Chart). This is placed at 6 meters distance from the observer and record made of the smallest line of letters which he is able to distinguish with

each eye separately. If vision is normal, a particular line of letters which may be designated as No. 6 will be distinguished without difficulty. In general, visual acuity is expressed by a fraction, the numerator of which is the distance at which the test is conducted, the denominator the line of type designated. Thus vision 6/12 means that the acuity is but one-half normal, the lines marked No. 12 on the card being seen at a distance of 6 meters

Wavelength

The length of the wave of a light ray, assuming the undulatory theory. The wavelengths of light rays vary throughout the spectrum inversely as the frequency.

Wavelength × frequency = Speed of light.

The measurement of wavelength of visible radiation is expressed in *microns, milli-microns or angström units,* q.v.

White Bowl Lamp

An incandescent lamp the bowl of which is covered with a hard white diffusing coating.

The action of the coating is that of a reflector which redirects the downward light of the lamp up to the real reflector for redirection to the working plane. A small percentage of the light passes through the coating directly to the working plane.

White Light

This is a very ambiguous term and is often used in a loose manner. Natural light, or daylight, is commonly referred to as being white, yet the color of natural light varies over a really wide range, depending on whether the major portion of the light is received from the sky or directly from the sun, on the position of the sun, etc. Nevertheless, natural light is approximately white in the general conception of the term. A more accurate terminology however, classifies white light as the color of a black body (q.v.) raised to a certain temperature. Some authorities use 5000 degrees absolute, others 7000 degrees absolute.

Such light represents a combination of luminous flux of many wavelengths from approximately 0.4 to 0.7 μ (*see Wavelength*). If white light is passed through a prism we have a complete spectrum of all the colors.

The light from the incandescent lamp is often referred to as being white, but it is well understood that it is slightly yellowish. On the stage, if white light is spoken of, the ordinary unmodified light from arc or incandescent lamps is meant. This is also true of signal lights and headlights.

Whiteway Lighting

Ornamental high intensity street illumination for spectacular purposes in downtown business districts.

Wing Tip Light

A headlight on an airplane usually placed at the tip of the wing.

Working Plane

In the design of lighting installations for use in factories, mills, and other work places, a plane in which the work is presumed to be done. It is ordinarily assumed to be about 30 inches above the floor.

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